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Using the Work System Method with Freshman Information Systems Students

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Executive Summary

Recent surveys of information technology management professionals show that understanding business domains in terms of business productivity and cost reduction potential, knowledge of different vertical industry segments and their information requirements, understanding of business processes and client-facing skills are more critical for Information Systems personnel than ever before. In an attempt to restructure the information systems curriculum accordingly, our view is that information systems students need to develop an appreciation for organizational work systems in order to understand the operation and significance of information systems within such work systems.

Work systems are systems in which human participants and/or machines perform work to produce products and/or services for internal or external customers. This view stresses that systems in organizations involve more than an IT system (such as a data warehouse or an accounting application). The work system method has been designed to assist in developing an understanding of work systems in organizations. The method describes an adaptable set of steps that an analyst can use to identify a work system, clarify problems, issues, and opportunities related to that work system, identify possible directions for change, and produce and justify a recommendation.

To date, the use of the work system method in information systems curricula has demonstrated that postgraduate students can benefit from this approach when examining a business situation involving an information system. To contrast the experiences of post-graduate students with work experiences, in this paper we report on use of a simplified version of the Work System Method in a freshman Information Systems course and study how students without work or technical knowledge performed when analyzing IT-reliant work systems in business settings. We reflect on an introductory information systems course that included a work system analysis assignment, and we examine the reports produced by students as well as the learning outcomes and challenges.

Our analysis reveals that undergraduates can benefit from analyzing IT-reliant work systems through the work system method. Their analyses tend to reflect their lack of business background, but doing these analyses can help as a first step toward appreciating the business situations in which information systems are used. We present a series of implications for improving the class experience related to teaching work system ideas

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and including IT-reliant work systems as an essential part of an introductory information systems course. These implications relate to clarifying the scope of a work system analysis, providing examples of successful as well as unsuccessful analyses for guidance, providing relevant analysis templates, succinctly defining terminology and assisting in emphasizing the differences between technologies, work systems, and organizations. Perusing these recommendations, our work demonstrates how information systems students can start developing a holistic understanding of information technology in use in corporate organizations at a very early stage of their learning process.

Keywords: Information system education, introductory information system course, work system, work system method.

Introduction

Universities in many countries have been reviewing their curriculums to ensure that students are offered degrees that will equip them well for life in a world of global forces and rapid change. Many of these curriculum changes recognize the importance of information technology and the challenges of "information technology in use in a modern world" (Miliszewska, Venables, & Tan, 2010), which is the core application field of the information systems (IS) discipline (R. J. Paul, 2010).

In examining the key skills that IS graduates should posses in order to cope with the importance of IT in today's world, the latest ACM and AIS model curriculum posits the following essential capabilities to be developed in IS graduates (Topi et al., 2010):

- Improving organizational processes,
- Exploiting opportunities created by technology innovations,
- Understanding and addressing information requirements,
- Designing and managing enterprise architecture,
- Identifying and evaluating solution and sourcing alternatives,
- Securing data and infrastructure, and
- Understanding, managing and controlling IT risks.

Several of these capabilities have been examined closely in education literature, for example, in reflections on teaching database security (Murray, 2010) or web technology (Zhang & Olfman, 2010).

These and related pedagogical articles have in common that they pertain most closely to students in the midst (e.g., Kamoun & Selim, 2007; Murray, 2010) or even towards the end of their coursework program (e.g., Hunsinger & Smith, 2008; Venables & Tan, 2009). Limited attention to date, however, has been given to undergraduate introductory courses at the very beginning of a university program.

Undergraduate introductory information system courses at the beginning of a curriculum present a difficult pedagogical challenge because undergraduate students often have limited backgrounds in business (Firth, Lawrence, & Looney, 2008). If undergraduate IS courses focus primarily on computer applications such as Microsoft Word and Excel, they are not really IS courses, and in many cases simply repeat material that undergraduate students have learned in high school or other college courses. If those courses are basically technology courses (what is a computer, what is a network, what is a database) they still are not really IS courses and often seem unnecessary to the more tech-savvy students who have already used computers, the Internet, social networking, and wireless technologies. If those courses focus on types of information systems and on processes of building information systems, there are serious questions about whether the core subject matter will be meaningful to students with little business experience, whether it can be mastered at a level beyond "memorize and repeat," and whether such courses provide a strong introduction to relevant topics such as infrastructure, organization, strategy, ethics, and work practices. Recent studies of IT industry trends, such as the IT workforce study by Abraham et al. (2006) or the survey of information technology management professionals by Luftman and Zadeh (2011) confirm that understanding business domains in terms of business productivity and cost reduction potential, knowledge of different vertical industry segments and their information requirements, understanding of business processes and client-facing skills is more critical for IS personnel than ever before.

Responses to these events and changes have included several calls for new and innovative IS curricula (Albrecht, Romney, Lowry, & Moody, 2009; Bullen, Abraham, Gallagher, Simon, & Zwieg, 2009; Carlsson, Hedman, & Steen, 2010; Helfert, 2008). This paper follows the call for innovation in IS curricula by focusing on curriculum design for introductory IS courses on an undergraduate level. It reports on an effort to incorporate a work system project into an introductory information system course for freshmen at a major university in Australia. In addition to covering typical introductory material such as hardware and software technologies, relevant concepts such as database and knowledge management, development methodologies, and managerial and social issues of information technology, this introductory course required teams of students to write a major paper concerning an IT-reliant work system, i.e., a system in which human participants and/or machines perform work to produce products and/or services for internal or external customers, and which relies on IT to operate (Alter, 2003, 2008). The pedagogical goal was to make sure that students would appreciate why information systems are an integral part of the work systems through which organizations operate. Achieving this goal would help them develop a holistic understanding of the importance of information systems in organizations, including relationships to business strategy, organizational and technological infrastructures, people, and everyday work practices. That type of holistic understanding, in turn, would strongly support the guiding assumptions of the latest IS model curriculum (Topi et al., 2010).

This paper proceeds as follows: It presents a brief overview of the ideas underlying work systems and the corresponding method for analyzing IT-reliant work systems. The explanation of the course setting includes descriptions of the students, the course, and the assignment related to IT-reliant work systems. The analysis includes examples illustrating the types of papers that were most successful, factors that limited the success of other papers, and a qualitative examination of the learning results obtained in the course. A series of implications for teaching provides recommendations about how to use this type of assignment to make it more likely that undergraduate students with little or no business experience will nonetheless develop a basic appreciation of the essence and significance of information systems in organizations.

Background

Viewing Systems as Work Systems

The idea of viewing systems in organizations as work systems evolved iteratively through information system courses for MBA and Executive MBA students that emphasized IT-reliant work systems in organizations.

The work system method builds upon a static view of a current or proposed work system in operation, which is known as the work system framework and is shown in Figure 1. It describes nine elements that form the basis for describing and analyzing IT-reliant work systems in organizations.

The work system framework focuses on a work system's form and operation at a point in time and is designed to emphasize business rather than IT concerns. It covers situations that might or might not have tightly defined business processes and might or might not be IT-intensive. Table 1 summarizes the key basic terms of the work system framework.

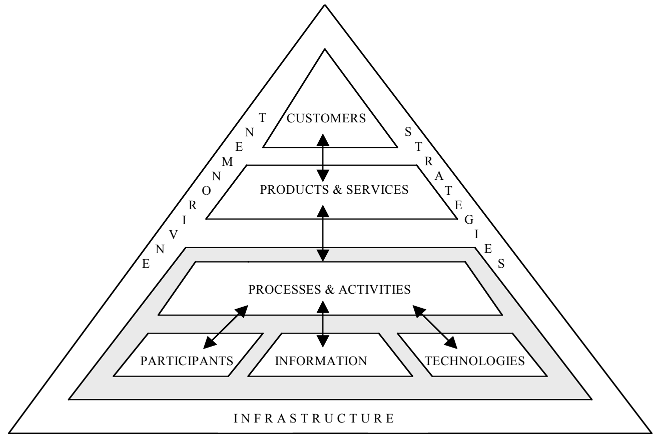

Figure 1: The Work System Framework. (Alter, 2006b), updated.

Table 1: Basic Terms Underlying the Work System Method (Alter, 2006b)

Basic Term	Definition
Work system	A view of work as occurring through a purposeful system.
Work system framework	A model for organizing an initial understanding of how a particular work system operates and what it accomplishes.
Customers	Are the people who receive, use or benefit directly from products and services that a work system produces.
Products and services	Are the combination of physical things, information, and services that the work system produces for its various customers.
Processes and activities	Include all of the work practices within the work system, including structured business processes and unstructured, perhaps improved activities.
Participants	Are people who perform the work.
Information	Includes codified and non-codified information used and created as participants perform their work.
Technologies	Are tools that help people work more efficiently.

The main premises for visualizing systems in organizations as work systems are summarized next. More detailed discussions are presented in Alter (2006b, 2007, 2008). The use of the work system method as a pedagogical instrument is discussed in detail by Petkov, Petkova, Sewchurran, Andrew, & Misra (2012).

Premise No 1: Organizations operate through work systems.

Work systems are systems in which human participants and/or machines perform work to produce products and/or services for internal or external customers. Typical examples of work systems in organizations include designing products, finding customers, selling to customers, manufacturing, products, providing services, distributing products, hiring employees, paying payroll, producing corporate plans, and so on. Table 2 lists representative examples of work systems selected and analyzed by over 300 advanced MBA students at a large public US university as part of core MBA courses between 2009 and 2011.

Table 2: Examples of work systems analyzed by MBA students (Truex, Alter, & Long, 2010)

Examples	Examples (ctd.)	Examples (ctd.)
Timekeeping for field technicians for a public utility	Performing portfolio management in a wealth management group	Finding and serving sales consulting clients
Receiving materials at a large warehouse	Scheduling and tracking health service appointment	Determining government incentive for providing employee training
Controlling marketing expenses	Determining salary increases	Performing financial planning for wealthy individuals
Acknowledging gifts to a high profile charitable organization	Operating an engineering call center	Planning for outages in key real time information systems
Performing pre-employment background checks	Administering budgets for grants	Approving real estate loan applications
Purchasing advertising services through an advertising agency	Collection and reporting of sales data for a wholesaler	Acquiring clients at a professional service firm
Planning and dispatching trucking services	Determining performance-based pay	Invoicing for construction work
Insurance policy renewals		

Premise No 2: Most work systems in organizations are IT-reliant.

Most work systems cannot operate efficiently or effectively without the support of information systems. Developing an information system without a substantial understanding of the work system that is to be supported is a recipe for confusion and disappointment. Some of the IT-reliant work systems that are discussed in the IS field are not fully "digital" because they involve physical components (e.g., manufacturing systems, delivery systems, retailing systems). Other IT-reliant work systems that are discussed in the IS field are pure information systems because they are totally devoted to processing information (e.g., Internet search, e-commerce for downloadable products). In either case, the nine elements of the work system framework reveal that an understanding of a work system involves much more than documentation of a business process' information, and technology.

Premise No 3: Business professionals need to think about work systems in order to understand the operation and significance of information systems.

The traditional IS-centric and IT-centric ways of talking about information systems are essential for programmers and programming projects but are incomplete for business professionals and for IT professionals who intend to collaborate and communicate effectively with business professionals.

Premise No 4: For business professionals, “the system” of interest is usually a work system, not just the information system that supports it.

Since business performance is an aggregation of work system performance, business professionals should see most business information systems as a means for operating or supporting work systems. From a business viewpoint, the success of an information system is fundamentally about how well it supports the behavior of one or more work systems. Likewise, from a business viewpoint implementation means implementation of a new or improved work system, which includes changes in information systems as well as other changes that may or may not involve information systems.

Premise No 5: A work system's life cycle involves iterations of planned and unplanned change.

The various types of SDLC (systems development life cycle) models are basically project models. In contrast, a work system life cycle model (WSLC) describes how work systems evolve over time through a combination of planned change executed through projects and unplanned change that occurs through local adaptations and experimentation outside of formal projects (Alter, 2003, 2006b, 2008).

Premise No 6: The work system view of systems is different from traditional systems analysis views.

The view of “systems” in the work system approach differs from the typical view of systems in systems analysis textbooks. In the work system approach, the unit of analysis is a socio-technical work system defined as a system in which human participants and/or machines perform work using information, technology, and other resources to produce products and/or services for internal or external customers (Alter, 2006b). This view stresses that systems in organizations involve more than an IT system (such as a data warehouse or an accounting application, for example). In contrast, traditional systems analysis and design books often view the “system” only as a technical, computer-based artifact that requires architecture, components, modules, interfaces, and data. For example, in a summary of the design phase of the software development lifecycle, Hoffer, George, and Valacich (2007, p. 13) say “analysts must design all aspects of the system, from input and output screens to reports, databases, and computer processes.” The work system view is therefore more encompassing as it also allows for the consideration of work systems that do not rely on information technology or computer-based systems altogether.

The Work System Method

The work system method (WSM) is designed to assist in developing an understanding of work systems in organizations. The method describes an adaptable set of steps that an analyst can use to identify a work system, clarify problems, issues, and opportunities related to that work system, identify possible directions for change, and produce and justify a recommendation. It is organized around a typical problem solving approach of defining a problem, gathering and analyzing appropriate data, and generating and selecting a preferred alternative. WSM has evolved over many years and has been described at various levels of detail, including various templates that allow deeper analysis if desired (Alter, 2006b; Petkov et al., 2012; Truex et al., 2010).

Previously, the work system method was explored as a teaching tool mostly at a postgraduate level. Many MBA and Executive MBA students, for instance, have used the work system snapshot successfully when launching discussions of work systems in their own organizations (Alter, 2006a; Truex et al., 2010). More recently, some authors have explored how the work system method can be used in undergraduate teaching. Ramiller (2005), for instance, describes the use of the work systems concept in an undergraduate IS course for the purpose of understanding the notion of business processes, and Petkov and Petkova (2006, 2008) applied it as a vehicle for improvement of student understanding of a business situation involving an IS implementation problem. In this paper, we specifically explore the application of the work system method in an introductory freshman IS course.

WSM is divided into three major steps: Step one is identifying the system problem (SP), step two is analyzing the system and identifying possible areas for improvement (AP), and step three proposes recommendations and justifications (RJ) for these changes. In this paper we emphasize the first two steps because this reduced scope reflects the boundaries set for the student reports. This limit allowed students to focus on the tasks of analyzing and improving IT-reliant systems in a holistic manner without moving too close towards technical implementation or other technical or organizational aspects of change.

Across the three steps, the WSM can be used at three levels of detail:

Level one encourages the user to think about the situation at hand in work systems terms. It provides a set of headings to encourage attention to each of the three main steps (SP, AP, and RJ) without providing further guidance.

Level two provides, for each step in the level one analysis, a set of important questions that are relevant to almost any analysis of a system in an organization, IT-reliant or not. The questions serve as a checklist to ensure comprehensiveness and completeness of any system analysis project.

Level three identifies specific topics that are worth considering when answering the questions at level two. It serves as a toolbox of topics, methods and guidelines, providing a direction for looking at frequently important topics related to the elements of the work system under analysis. Checklists, diagrams and templates are provided to organize concepts and knowledge in an easily accessible form. In our particular teaching setting, level three was excluded from the scope of the reports, because the use of level three is optional and serves as means for a deeper analysis of the findings reported on level two.

Table 3 summarizes the steps and levels of the work system method. In Table 3, the focus of the student reports we examine in this paper are highlighted gray.

Table 3: Three Levels of the Work System Method

	First step in WSM (System and problem)	**Second step in WSM (Analysis and possibilities)**	**Third step in WSM (Recommendation and justification)**
Headings in Level One	SP: Identification of the work system that has the problems or opportunities.	AP: Analysis of current issues and identification of possibilities for improvement.	RJ: Recommendation and its justification.
Questions in Level Two	SP1 through SP5: Five questions about the system and problem.	AP1 through AP10: Ten questions related to analysis and possibilities.	RJ1 through RJ10: Ten questions related to the recommendation and its justification.
Topics and guidelines in Level Three	Checklists, Templates, and Diagrams	Checklists, Templates, and Diagrams	Checklists, Templates, and Diagrams

As displayed in Table 3, the simplified version of WSM that was used in the teaching experience reported here focuses on identifying the work system and its main problems, issues, or opportunities, and then analyzing the work system and identifying possibilities for improvement. To make the student assignment practical in an introductory course, the assignments did not include presenting and justifying recommended changes in the work system, although students were allowed to propose improvements if they wished to do so. Appendix A summarizes the instructions the students received for applying a simplified version of WSM.

Analysis as part of the work system method typically begins with using a simple and widely applicable tool called a *work system snapshot* (Alter, 2006b). A work system snapshot is a one-page summary of a work system that identifies the main components of six central elements of the work system framework as defined in Table 1, viz., customers, products and services, processes and activities, participants, information, and technologies. Table 4 shows a work system snapshot produced by one of the freshman student teams whose submissions we examine in this paper. At the beginning of the analysis of a work system, the work system snapshot helps in clarifying the scope of the work system and identifying the most important things that it produces for its customers. A more detailed view may then drill down by explaining specifics about each of the snapshot elements in a particular situation. Other tools that are useful in analyzing work systems can be applied as the analysis proceeds.

Table 4: Sample Work System Snapshot of an intercampus book transfer work system, produced by college freshmen

Customers	Products & Services
Current university Staff	Report
Current university Students	Email
Lending Service Staff	Book Delivery
	Book Collection

Work Practices (Major Activities or Processes)
At 7am and 11am, Lending Services Staff (LSS) generates a report from Library Information System (LIS).
LSS scans the book(s) barcode to update LIS and place into transfer bin/box.
LIS changes book(s) status to “In Transit”.
At 9am and 1pm, courier staff picks up transfer bin from campus.
Courier staff delivers transfer bin to another campus.
LSS at another campus receives the book(s).
LSS scans the book(s) barcode and update the LIS.
LIS changes book’s status to “Ready” and automatically sends pick-up notification email to student(s) or staff.
LSS put books on hold shelf.

Participants	Information	Technologies
Lending Service Staff	Book’s details	Computer
Courier Staff	Student’s details	Barcode Scanner
Students	Staff’s details	Van
	Transfer request report	Bin/Box Printer
		Paper
		Internet
		Email System

Notice in Table 4 how freshmen were able to produce a work system snapshot that is understandable and clear enough that it can serve as a basis for further analysis that would look at the elements in more detail, perhaps by using flow charts, anecdotes, and data related to work system performance.

Introduction to the Teaching Setting

The introductory Information Systems course we examine in this paper is a freshman course offered at Queensland University of Technology in Australia. This course is available both as a mandated course within the Bachelor of Corporate Systems Management degree and as an elective course for business and IT students with a major in Corporate Systems Management. The course's goal is to introduce freshman students broadly to the field of Information Systems. To that end, the course gives a broad overview of the nature and role of socio-technical information systems in corporate business settings and of the role that corporate systems managers perform within the major business domains in which they operate.

The course is taught regularly in the first semester of each academic year and attracts between 120 and 190 students overall. More than half of the students come from other countries and bring forth different educational backgrounds. Most students are full time students; around 5 to 10 are part-time students who work as business, system, or process analysts in consulting companies or the corporate business or IT departments of large corporations. Given our focus on the performance of college freshmen, we excluded the (small) percentage of students with business background or working experience. Thus, our research covers a much younger and less experienced student population than was covered in previous pedagogical research involving post-graduate students and upper level undergraduates (Alter, 2006a; Petkov & Petkova, 2008, 2010; Truex et al., 2010).

The course teaches topics relevant to information systems and their management, consistent with current guidelines for IS teaching curricula (Firth et al., 2008; Ives et al., 2002). The course comprises the following four content blocks. For three of these four blocks, the standard textbook by Kenneth and Jane Laudon ("*Management Information Systems: Managing the Digital Firm, 9th edition*") was used.

1. Basic concepts and fundamentals of corporate information systems.
2. The role and challenge of corporate information systems management.
3. Different types of corporate information systems for key organizational tasks.
4. Recent trends and future developments in corporate information systems.

In this paper we look at block 2, where the Work System Method was introduced as an approach for communicating, describing, analyzing, and improving IT-reliant systems from a managerial perspective. This block spanned three out of thirteen lecture weeks (weeks 4-6), with each lecture week comprising a 2-hour lecture and a 1-hour tutorial. Overall instruction time pertaining to the work system method was nine hours.

The student reports we examine in this paper are part of an assignment due in week 12 of the course. The assignment officially started in week 6, allowing the students overall eight weeks for completion (seven lecture weeks plus a mid-semester break of one week length). The assignment was worth 30 % of the final mark in the course, with a further 30 % ascribed to the first assignment, and the final written exam being worth the remaining 40 %.

This assignment set out to increase students' awareness of the nature and role of corporate systems and the challenges related to their management in terms of communication, analysis and improvement. Students were asked to investigate the challenges of managing corporate information systems through an assignment using the simplified version of the Work System Method as described in Table 3.

The assignment task for the student was defined as follows.

In groups of four to six participants, students were asked to identify the case of an information system in use within a work system of a corporate organization. Students were free to select the case and were advised that such cases can be found described in computer or business magazines, or through students' work or prior experiences. Students were also allowed to use the case of the information system presented in a previous assignment. Students were informed to look for information about the corporate organization on the Web to gain further insight into the company and prepare a brief description of the business.

The students' task was to analyze the role and use of the selected work system within the corporate organization by taking a Work System View on the selected information system, the work system in which it is used, and the corporate organization. Specifically, students were asked to perform the following steps:

1. Review the case and summarize the work system. Produce a Work System Snapshot (see template provided) so that you can answer the following questions:
   a) Identify the main customers of the work system.
   b) Identify the main participants in the system.
   c) Identify the products or services produced by the system.
   d) Summarize the main relevant work practices in the system.
   e) Identify the information used and created by the system.
   f) Identify the technology used by the system.
   g) Identify those aspects of the surrounding environment, strategy and infrastructure that are relevant to the system.
2. Analyze the work system in greater detail, using the Work System Method. Perform an analysis using levels one (headings) and two (questions), and using Steps one (system and problem) and two (analysis and possibilities) of the Work System Method.

Students were asked to produce a written report detailing their findings from tasks 1 and 2 and to provide conclusions derived from the analysis. These conclusions could, but did not have to, include recommendations to the organization for further action.

In the report, the analysis was to be complemented by an introduction to the case organization and the work system selected, information about the work system method as an approach to describe and analyze information systems in corporate organizations, and an executive summary describing the most important results. Appendix A shows the assignment task and shows a sample report template provided to the students.

Student Results

In this section we examine differences between report examples selected from 20 reports from student teams to identify challenges in applying the work system method faced by undergraduate student teams. Table 5 provides an overview of the student reports received by summarizing selected student team topics and their findings.

Table 5: Main Conclusions in Selected Student Analyses of Work Systems	
Selected work system	**Selected analysis findings**
Inter Campus Book Transfer System	The unclear status of the books being transferred between different campuses of the university makes it more difficult for a book's requestor to figure out whether or not the book has arrived at his/her campus. Steps toward a more effective and efficient work system include simple modifications such as enhancing the clarity of terminology about a book's status throughout the work system, and providing easier and more visually oriented explanatory materials (e.g., process models or similar diagrams) for the information system used in the work system.
Roadside assistance	Strengths of the system are the award-winning service by Customer Care Assistants and straightforward structure of the work system, with appropriate procedures for role allocation and resource utilization. The work system's limitations and constraints include the existing infrastructure and absence of GPS in insured cars. Weaknesses include inefficiency of the supporting information system, interdependency of software modules within that system, and a rigid relationship to the information system's processes that could affect the performance of the work system as a whole.
Express E-ship System	Maintaining the infrastructure of this work system is expensive due to the high fixed costs.
Grocery Store Inventory Management System	Consumers are often confused with the complexity of the current work systems of package delivery, where they have difficulties in registering, and the tracking of the packages. Recommendations for system include improved training, streamlined work processes, and more user-friendly interfaces.
Flight Slot Management System for an international airport	Customers' main concern is the reliable availability of the products that they want to purchase. The work practices that are in place currently succeed in assuring that all products are of a high standard. Factors that impede work system success include inefficiencies of RFID guns and monetary and time constraints (e.g., order value limits, time-to-order limits).
Flight Booking System	Problems include a decrease of skilled staff, which increases human errors in performing work within the work system. Recommendations related to automating methods within the work system would affect the way that flight slot requests are dealt with, and how older information should be handled and stored for controlling and management information purposes. The customers who will be affected include Air Traffic Controllers, Flight Management Staff, Airport Management and the Civil Aviation Safety Authority.

In the following, we briefly review selected student papers to uncover the factors distinguishing successful from less successful reports and to identify major types of challenges that undergraduates faced when trying to analyze IT-reliant work systems. Students were informed that electronic copies would be kept. Examples presented in this paper are disguised where required.

We identified successful, average, and unsuccessful reports on basis of a marking criteria sheet that assigned a score of 0-30 marks for each report. We provide the assessment sheet in Appendix B. For the purpose of the analysis reported in this paper, we reviewed marks achieved in the core report sections "Work System Snapshot" and "Work System Method" and also considered the commentary by the teaching personnel marking the reports. Based on this data, we clustered the reports into the three classes, successful, average, and unsuccessful reports, as discussed next.

Examples of Successful Reports

Inter Campus Book Transfer System

The work system that transfers books between campuses of the university was somewhat familiar to the members of the student team. The paper presented an understandable work system snapshot and identified three significant problems with the existing work system (ambiguous status descriptions for books, inappropriate privileges, human errors). Although not required as per assignment instructions, the paper also recommended two work system changes that would ameliorate those problems (first, enhance the clarity of terminology related to a book's status throughout all processes within the work system; second, provide easier, perhaps diagrammatic, explanatory materials to the online information system used within the work system).

One reason for the success of this student paper was that the work system was relatively circumscribed and its work system practices involved participants and objectives that were relatively easy to understand. The more complicated a work system is, and the less familiar it is, the more difficult it is for students to visualize the system and perform an analysis.

Roadside Assistance

The work system provides roadside assistance to motorists who use mobile phones to contact a call center when a roadside incident occurs. Once again, the function of the work system was relatively circumscribed and could be summarized clearly using a work system snapshot. The team identified constraints (the existing infrastructure and absence of GPS in insured cars), strengths (award−winning service by Customer Care Assistants, the system's straightforward structure, and appropriate allocation of roles), as well as weaknesses (inefficiency of the information system, non-transparent interdependency of its modules, and its rigid relation to the work system's processes and other work practices).

The student team recommended improvements to the user ‑ interface of the information system, improvements in workflow efficiency, a review of the current work system overall to ensure its sustainability for future growth, and new business models (e.g., membership packages) related to the work system. This paper's success could have been due in part to notable extra efforts to conduct additional, detailed analyses, such as trying to identify measurable organizational value of the work system.

Examples of Average Reports

Dell Computer

A paper about Dell Computer was generally successful in demonstrating that the freshman team authors understood that Dell Computer operates through processes such as ordering inventory, accepting orders, and assembling computers. However, the paper revealed confusion about relationships between work systems containing those processes. For example, the first step in the paper's work system snapshot is that the customer sends an order to Dell. The next step is that Dell sends orders to its suppliers. A more accurate summary is that Dell decides what computers it wants to sell, orders the required components, and then uses those components to build computers within a few days of receiving customer orders. It is possible that the students who wrote this paper might have been able to learn more about how Dell's value chain operates. The student paper cited privacy as the main issue for this work system. More thorough research about Dell probably would have identified other issues, or possibly opportunities related to improving efficiencies or enhancing product offerings. Nonetheless, the student paper revealed a relatively satisfactory understanding of Dell for students who are freshmen. It seemed likely that their research would help them understand many other corporate examples that they would encounter later in their coursework and careers, even though this first report revealed a number of problems. Those problems included including difficulties in describing the work system examined and difficulties in drawing correct conclusions from a thorough analysis of the elements involved.

Grocery Store Inventory Management System

The team identified major steps within an inventory management at a local grocery store (e.g., ordering, product placement, and stock calculations) and identified capabilities within information systems (e.g., an order management system) and technologies (e.g., RFID guns). The work system snapshot identified sets of work system participants (e.g., management personnel, store staff, delivery personnel).

The recommendations were the main area of concern for this team. Although it made recommendations (e.g., a web-based information system for order management, better algorithms for stock calculations), it struggled in identifying which steps specifically could benefit from the use of an upgraded order management information system and how products and practices would change in an improved IT-reliant work system. The analysis of the work system's fit to the organization's environment had other shortcomings. Important processes and IT interfaces were neither identified nor examined by the students, so that no recommendations could be made as to how to improve the overall position of the work system in the inter-organizational supply chain of the grocery store and its suppliers.

Examples of Unsuccessful Reports

Large Retailer

The student team obtained information about a large retailer, yet failed to identify any clearly defined work system within the organization. They cited a number of facts that were related to topics in the course, but did not present those facts in a way that led to meaningful, justified conclusions. Their work system snapshot revealed confusion about what a work system is and what activities and processes mean in the context of a work system. Their paper revealed difficulties in identifying the work system, such as misunderstandings about activities and processes in the context of a work system. Their work system snapshot included statements that did not belong in a work system snapshot, such as "a customer expects good customer service from a company," "several other departments' officers and heads use computers and IT extensively whereas other may use little or no technology," and "an additional benefit now includes subsidized catering facilities." Similarly, the students failed to identify the set of products and services generated through the work system (the products/services named by the students included "Plan A" and "Customer Cheque & invoices"). The inadequate identification of the work system and its constituent elements made it difficult for the students to perform a meaningful analysis and, therefore, to provide justifiable recommendations.

Ebay

The student team failed to report specifically on any work system within the eBay organization and, instead, offered statements about the organization in general. Students studying eBay using the work system approach could potentially consider the auction system as the work system. That work system would probably start when a seller creates an auction and would end when an auction ends with a winning bid or when the buyer pays for the item or receives it. Inspection of the student report revealed a misplaced focus on describing the work system method rather than the work system being studied. In other words, the students misunderstood the assignment.

Challenges for Students

The assignments submitted by freshman student teams revealed a number of difficulties and confusions, of which the following occurred at least several times:

A number of papers revealed confusions about basic WSM terms and concepts. For example, one paper contained the following statement, "*A Work System Method has been modeled to derive a clear understanding of the business and its processes*." Another paper said, "*This report sets out to establish and analyze the Work System Method*." These teams and several others did not fully understand that WSM is a method of analyzing a system in an organization and that a work system model starts with the work system snapshot. They were confused about the difference between the method, the snapshot, and the underlying concepts. Several similar examples in less successful papers illustrate the need to make sure that terminology and abstractions are well-defined and carefully discussed in class.

A number of papers revealed confusion between work systems and information systems. The goal of the work system method is to improve the work system. Those improvements may include improvements to the information system and/or improvements to parts of the work system that do not touch the information system. The latter distinction is a bit subtle for undergraduates in the context of an introductory information system course. It is noteworthy, however, that this distinction is sometimes overlooked even in the larger context of the IS field, which often does not distinguish clearly between work system improvements that result directly from information system changes and other work system improvements that may have happened at the same time but were not directly related to the information system changes.

A number of papers revealed confusion about the scope of the analysis. Some of the less successful reports (e.g., eBay) and even some of the moderately successful reports (e.g., Dell) had problems in defining the focus of the analysis. A scope-related problem in some of the reports was that a team considered organizations that operated on an e-commerce business model (e.g., eBay, Amazon, Facebook) to be a single work system, instead of identifying specific work systems within these organizations (e.g., an auction work system or a book ordering system). In these cases, there was some confusion between organizations whose business models are enabled through information systems and specific work systems that rely on information systems.

A number of papers revealed inadequate critical thinking. We identified a number of occurrences of inadequate critical thinking (R. W. Paul & Elder, 2002) in the student reports, in some cases similar to challenges faced by postgraduate students when analyzing IT-reliant work systems (Alter, 2006a). Such problems were revealed in confused understandings of important IS concepts, difficulty in presenting and applying evidence, or poorly justified recommendations. Of the ten common problems related to critical thinking identified by Alter (2006a), we found shortcomings related to the following aspects of critical thinking:

- Defining the problem (clarifying scope, limits, and essence of the problem)
- Gathering information and evidence (arguing on the basis of relevant information rather than on the basis of unsupported opinions)
- Drawing inferences and interpretations (interpreting information appropriately)
- Searching for alternatives (identifying possibilities and clarifying the range of options)
- Drawing conclusions (offering recommendations that are supported by evidence or analysis)
- Presenting a coherent and complete argument (explaining relevant facts and findings)

Student Feedback

We gathered preliminary evidence for the perceived effectiveness of the Work System Method as a teaching tool in an undergraduate IS course by examining qualitative responses from the formal unit evaluation data gathered at Queensland University of Technology in 2009 when WSM was introduced into the course.

At Queensland University of Technology, students are asked for anonymous feedback at the end of every semester through a standardized online feedback form. This form asks the students to assess relevance, difficulty, workload, assessment and relevance of the content as well as the delivery of the teaching through the instructors through a 5-point scale. Additionally, and for our purposes more importantly, the evaluation mechanism also allows students to comment freely on the various aspects of the course, including the assessments.

Inspecting the qualitative feedback from the student comments relating to the WSM assignment, we find that the inclusion of the WSM assignment was perceived as mostly positive, as illustrated by the following comments:

- *The group assessments allowed me to relate the subject to a real life situation that might happen to me in future.*
- *We learn more about the work systems within a business/company, which lets us understand more about how the business works.*
- *You get to know more about IT, what systems are made of IT how they are related to the organizations.*
- *The Work System Method is a great tool that can be applied to any organization. [The assignment] sparked interest in information systems application to industry.*
- *Learning about business aspects, this gives a good insight in the workings of IT systems in different businesses.*

These and other similar comments indicate student recognition that WSM helps in understanding how information systems contribute to business practice.

Recognition of the practical relevance of the approach also became evident from the comments. Specifically, some students found that the work system method allowed for a close integration between theoretical content and their practical application in their day-to-day jobs:

- *The best thing I found was that I was able to apply my existing knowledge of work systems and corporate information systems, gained from working in business for 6 years, to the course content. My group did both assignments on scenarios from my current workplace. I found it great that we were able to do this, as it improved my understanding both of the course content and also of my job.*

Regarding disadvantages of the WSM, some of the feedback received pointed to the large amount and complexity of the work required *("Group assessments were too complicated." "Too much work and group work."*). Notably, the business focus on information systems provided by the WSM was also seen as a challenge by some students: *"As not taking a business course, it's kind of hard to blend in during lectures; the material is talking deep inside a business."* Especially for freshmen students with little to no work experience, it was felt that some parts of the WSM approach were challenging to comprehend:

- *I could apply knowledge I have gained from working with information systems in corporate organizations. However it felt like the work system method was catered more to my level (that is, students who already had some understanding of the topic through work) rather than at the level of some of my friends (no experience working in business, and found it difficult to relate to some of the content).*

We recognize the difference between collecting student feedback versus collecting rigorous data on learning outcomes. Nonetheless, a large share of student comments about the inclusion of WSM as a part of the course was positive. While not discussed here in detail, the overall course ratings, too, were significantly improved on previous years, which seems to indicate that inclusion of a major project based on WSM contributed to improvements in the units across all evaluation criteria. Of course, we recognize that other factors such as experience, change of teaching team, and/or improved teaching skills will also have contributed to the improvement of the course.

Implications for Teaching

The successes and difficulties that we observed lead to a number of implications for presenting work system concepts and using them in major class assignments for undergraduates with no or little business experience. We summarize these implications in the following recommendations:

Be clear about the assignment. Although most students understood that they were supposed to use work system ideas to perform an overview level analysis of a work system in an organization, several student teams believed they were supposed to describe the possible relevance of a work system approach to a specific situation. A straightforward way to address this type of issue is to provide examples of effective and ineffective analysis and to provide appropriate templates that will guide the student analysis effort.

Provide examples showing effective and ineffective analysis. One of the ways to guide student assignments is to preempt mistakes they might make by showing examples of effective and ineffective work. A good example is the difference between effective and ineffective work system snapshots. Table 4 presented an example of a good work system snapshot produced by a student team. In contrast, Table 6 shows an ineffective work system snapshot.

Table 6: Example of an ineffective work system snapshot (Alter, 2009)

Customers	Products & Services
Applicant	Loan

Work Practices (Major Activities or Processes)
Find applicants
Produce loan application
Approve or decline
Send paperwork

Participants	Information	Technologies
Applicant	Application	Telephone
Loan office		Spreadsheet
Committee		Word processor

Notice how Table 6 provides so little information that many important topics are unclear, such as who performs which activities, what information they really use, whether this system actually produces a loan or something else, and whether this work system has customers other than the loan applicant.

Provide templates for analyzing a work system. Another way to help students write good papers and to help them learn work system concepts is to provide templates for analyzing a work system. Potential templates include a fill-in-the-blanks section for identifying major problems or opportunities and constraints, a blank table for identify important metrics for the work system along with important performance gaps, and a blank work system snapshot for summarizing the work system under analysis. Truex et al. (2010) report on using this type of approach successfully with advanced MBA students.

Clarify terminology. Some of the student papers revealed confusion about basic terminology and concepts. Here are some of the clarifications that would have helped, and which could be provided in the form of a terminology or dictionary handout:

- Work system: A system in which human participants and/or machines perform work (processes and activities) using information, technology, and other resources to produce specific products and/or services for specific internal or external customers.
- Work system framework: A framework identifying nine elements that inform a basic understanding of a specific work system.
- Work system snapshot: A one-page summary of a specific work system in terms for six elements: customers, products and services, processes and activities, participants, information, and technologies.
- Work system method: A systems analysis method that uses work system ideas for understanding and analyzing systems in organizations. The work system method uses the work system snapshot and many other concepts and tools.

The terms in the work system framework should also be defined carefully. For example, customers receive and use products and services that the work system produces for purposes other than doing work within the work system itself. Customers may be work system participants (as in self-service with ecommerce), but work system participants need not be work system customers.

Provide familiar examples of work systems. A good way to introduce work system concepts is to ask students to produce work system snapshots of work systems they are familiar with, such as how a video store works, how a library works, or how university registration works. One approach is to ask each student to produce a work system snapshot of a familiar work system and to bring three copies of it to class. In class, students work in teams of three, with each student passing his/her work system snapshot to the other two teammates. Without any help from the author of the work system snapshot, a student who receives a work system snapshot should read it quickly and then try to explain that work system to the other two students. It soon becomes clear that a good work system snapshot with an adequate amount of clearly stated information is a good summary of a work system, and that incomplete or sloppy work system snapshots are difficult to understand. Through a debrief after this exercise, the lecturer can reinforce issues such as what each work system snapshot really means and indications of whether a work system snapshot is good or not.

Emphasize the difference between a technology, a work system, and an organization. A number of student teams were confused about whether they were to analyze a work system within an organization or whether the organization was a work system (e.g., the eBay example mentioned earlier). Although it is possible to think of an entire organization or enterprise as a single work system, usually that is not useful for analysis because an entire enterprise typically comprises a large number of work systems and contains too many people in different roles performing too many different activities. Simply using a set of examples to illustrate the difference should suffice in making this point. Other students were confused about whether they were supposed to report on technologies that were used or on how technologies enabled the operation of work systems.

Treat the scope of any work system as a choice, not a given. Students should realize that the scope of a work system depends on the problem or opportunity that is being analyzed. The general rule of thumb is that the work system is the smallest work system that has the problem or opportunity that is being studied. That rule of thumb is reasonably effective when business professionals use a work system approach for thinking about business problems and issues. It may be less effective when undergraduate students use work system concepts to describe business situations that they learn about through secondary sources.

Be sure that students analyze appropriate work systems. Ideally students should analyze work systems to which they have some access though a job, friend, or family member. Student teams can be formed around such opportunities, since some students will not have the appropriate contacts. It is also possible to form student teams around topics that can be researched through secondary sources such as magazines, newspapers, and corporate information that can be found using Internet search engines. Table 7 is part of a list of work systems that one of the authors has provided to student teams that lack personal access to an appropriate real world system. Further information about these and other work systems is sometimes available in major newspapers, published case studies, IT-related periodicals such as *CIO Magazine*, *CIO Insight*, *InformationWeek*, *Baseline*, and *Computerworld*, and business periodicals such as *Bloomberg BusinessWeek*, *Fortune*, *Forbes*, and *Fast Company*.

Regardless of whether information about the work system is obtained through primary or secondary sources, it is useful to check that students are analyzing appropriate work systems. This can be done by asking that students submit a work system snapshot and a brief summary of the problem or opportunity soon after they start the project and well before it is due.

Table 7: Possible Work System Topics for Student Reports Based on Secondary Sources

Examples	Examples (ctd.)	Examples (ctd.)
Billing in law firms or other professional service firms	Producing animated movies	Compliance with Sarbanes Oxley legislation (reducing costs)
FBI's Virtual case file	Controlling traffic	ChoicePoint – controlling access to information
Air traffic control	Moving packages (FedEx, UPS)	Insurance sales systems
IRS information system	Virtual office	Agile software development
Trading in stocks or bonds	Industrial sales systems	Taking orders for a new cell phone or land line
FBI's Virtual case file	Use of CAD (computer aided design) in surgery	Netflix
Controlling commercial airplane flights	Electronic medical records	Order fulfillment at Zappos.com (or other interesting ecommerce site)
Vendor managed inventory	Customs clearance for ports	Supply chain in clothes retailing
Reordering in grocery stores or department stores	Boeing's supply chain and supply chain issues for its new Dreamliner airplane	Kaiser Permanente's new medical records system
Risk control systems in a large investment bank or brokerage	Payment Card Industry Data Security Standard – how and how well it operates	Voting systems
Airline passenger screening	Managing call centers	Financial planning process at a large company
Billing battles related to health claims	Entering and fulfilling orders in restaurants	RFID at Wal-Mart

Recognize limitations related to student background and interest. A work system assignment in a freshman course should be viewed as a starting point for novice level understanding that will improve over time with subsequent work and study experiences. The common lack of business experience makes it more difficult for most undergraduate students, and especially freshmen, to appreciate the significance and meaning of information systems and their support of work systems in organizations. Although understanding work systems is challenging in the same way, at least the relationship between work system performance and business performance is more direct and easier to visualize. For example, it is reasonably straightforward that outstanding performance by a firm's manufacturing or sales work systems tends to generate high levels of efficiency and revenue. The work system assignment helps students understand that organizations operate through work systems and that IT and information systems play a crucial role in work system performance.

Conclusion

The goal of an introductory information systems course is to provide the understandings needed by IS students as well as those students majoring in IS as part of their business or IT degree (Firth et al., 2008). This paper discussed experiences using the Work System Method for teaching freshmen students about the management of information systems in business settings, with a focus on their ability to identify, analyze, improve, and communicate about the role of information systems in organizational work systems.

We described the lessons and challenges with using this approach in teaching freshmen. Our recommendations for using WSM effectively with freshmen can be summarized as follows:

- Provide greater clarity about basic ideas about work systems and the analysis of work systems,
- Provide examples that illustrate effective vs. ineffective work system snapshots,
- Help students find appropriate examples of work systems (such as the ones provided in Table 2 or Table 7), and
- Provide early feedback about whether student teams are studying work systems that are sufficiently focused.

We conclude that the work system approach can help freshmen and other undergraduates develop an understanding of some of the fundamental relationships between work systems, information systems, and IT. Our experience with freshmen students indicates that the work system method is a suitable pedagogical tool for introducing inexperienced undergraduate students to information systems, their role in organizations, and the challenges related to their management.

Our work has limitations. This paper reports on the application of the WSM in the context of only one university. The effects on student performance and satisfaction may not transfer to student cohorts in other institutions. We used student feedback on teaching quality as an indication of the success of this approach. Future work could examine impacts on learning performance under conditions different from those reported in this paper.

References

Abraham, T., Beath, C. M., Bullen, C. V., Gallagher, K., Goles, T., Kaiser, K., et al. (2006). IT workforce trends: Implications for IS programs. *Communications of the Association for Information Systems, 17*(50), 1147-1170.

Albrecht, C. C., Romney, M., Lowry, P. B., & Moody, G. (2009). The IS core: An integration of the core IS courses. *Journal of Information Systems Education, 20*(4), 451-468.

Alter, S. (2003). 18 reasons why IT-reliant work systems should replace "The IT Artifact" as the core subject matter of the IS field. *Communications of the Association for Information Systems, 12*(23), 366-395.

Alter, S. (2006a). Pitfalls in analyzing systems in organizations. *Journal of Information Systems Education, 17*(3), 295-302.

Alter, S. (2006b). *The work system method: Connecting people, processes, and IT for business results*. Larkspur, California: Work System Press.

Alter, S. (2007). Could the work system method embrace systems concepts more fully. *Information Resource Management Journal, 20*(2), 33-43.

Alter, S. (2008). Defining information systems as work systems: Implications for the IS field. *European Journal of Information Systems, 17*(5), 448-469.

Alter, S. (2009). Example of an ineffective work system snapshot. *Teaching materials for MBA-6113*. San Francisco, California: University of San Francisco.

Bullen, C. V., Abraham, T., Gallagher, K., Simon, J. C., & Zwieg, P. (2009). IT workforce trends: Implications for curriculum and hiring. *Communications of the Association for Information Systems, 24*(9), 129-140.

Carlsson, S. A., Hedman, J., & Steen, O. (2010). Integrated curriculum for a bachelor of science in business information systems design (BISD 2010). *Communications of the Association for Information Systems, 26*(24), 525-546.

Firth, D., Lawrence, C., & Looney, C. A. (2008). Addressing the IS enrollment crisis: A 12-step program to bring about change through the introductory IS course. *Communications of the Association for Information Systems, 23*(2), 17-36.

Helfert, M. (2008). Business Informatics: An engineering perspective on information systems. *Journal of Information Technology Education: Research, 7*, 223-245. Retrieved from http://www.jite.org/documents/Vol7/JITEv7p223-245Helfert354.pdf

Hoffer, J. A., George, J. F., & Valacich, J. S. (2007). *Modern systems analysis and design* (5th ed.). Upper Saddle River, New Jersey: Prentice Hall.

Hunsinger, D. S., & Smith, M. A. (2008). Factors that influence information systems undergraduates to pursue IT certification. *Journal of Information Technology Education: Research, 7*, 247-265. Retrieved from http://www.jite.org/documents/Vol7/JITEv7p247-265Hunsinger360.pdf

Ives, B., Valacich, J., Watson, R. T., Zmud, R. W., Alavi, M., Baskerville, R., et al. (2002). What every business student needs to know about information systems. *Communications of the Association for Information Systems, 9*, 467-477.

Kamoun, F., & Selim, S. (2007). A framework towards assessing the merits of inviting IT Professionals to the classroom. *Journal of Information Technology Education: Research, 6*, 81-103. Retrieved from http://www.jite.org/documents/Vol6/JITEv6p081-103Kamoun223.pdf

Luftman, J., & Zadeh, H. S. (2011). Key information technology and management issues 2010–11: An international study. *Journal of Information Technology, 26*(3), 193-204.

Miliszewska, I., Venables, A., & Tan, G. (2010). Didactics of information technology (IT) in a science degree: Conceptual issues and practical application. *Journal of Information Technology Education: Innovations in Practice, 9*, 79-89. Retrieved from http://www.jite.org/documents/Vol9/JITEv9IIPp079-089Miliszewska826.pdf

Murray, M. C. (2010). Database security: What students need to know. *Journal of Information Technology Education: Innovations in Practice, 9*, 61-77. Retrieved from http://www.jite.org/documents/Vol9/JITEv9IIPp061-077Murray804.pdf

Paul, R. J. (2010). Loose change. *European Journal of Information Systems, 19*(4), 379-381.

Paul, R. W., & Elder, L. (2002). *Critical thinking: Tools for taking charge of your professional and personal life*. Upper Saddle River, New Jersey: Prentice Hall.

Petkov, D., & Petkova, O. (2006). Development of scoring rubrics for IS projects as an assessment tool. *Issues in Informing Science and Information Technology, 3*, 499-510. Retrieved from

Petkov, D., & Petkova, O. (2008). The work system model as a tool for understanding the problem in an introductory IS project. *Information Systems Education Journal, 6*(21), 3-12.

Petkov, D., & Petkova, O. (2010). *An exploratory study on the student acceptance of the work system method as part of the systems analysis and design course.* Paper presented at the 27th Information Systems Educator Conference, Nashville, Tennessee.

Petkov, D., Petkova, O., Sewchurran, K., Andrew, T., & Misra, R. (2012). The work system method as an approach for teaching and researching information systems. In Y. K. Dwivedi, M. R. Wade, & S. L. Schneberger (Eds.), *Information systems theory: Explaining and predicting our digital society, Vol. 2* (pp. 413-424). New York, New York: Springer.

Ramiller, N. C. (2005). Animating the concept of business process in the core course in information systems. *Journal of Informatics Education Research, 3*(2), 53-71.

Topi, H., Valacich, J. S., Wright, R. T., Kaiser, K., Nunamaker Jr, J. F., Sipior, J. C., et al. (2010). IS 2010: curriculum guidelines for undergraduate degree programs in information systems. *Communications of the Association for Information Systems, 26*(18), 359-428.

Truex, D. P., Alter, S., & Long, C. (2010). *Systems analysis for everyone else: Empowering business professionals through a systems analysis method that meets their needs.* Paper presented at the 18th European Conference on Information Systems, Pretoria, South Africa.

Venables, A., & Tan, G. (2009). Realizing learning in the workplace in an undergraduate IT program. *Journal of Information Technology Education: Innovations in Practice, 8*, 17-26. Retrieved from http://www.jite.org/documents/Vol8/JITEV8IIP017-026Venables706.pdf

Zhang, X., & Olfman, L. (2010). Studios, mini-lectures, project presentations, class blog and wiki: A new approach to teaching web technologies. *Journal of Information Technology Education: Innovations in Practice, 9*, 187-199. Retrieved from http://www.jite.org/documents/Vol9/JITEv9IIPp187-199Zhang813.pdf

Appendix A: Instructions Students Received for Applying a Simplified Version of WSM

Using the Work System Method, investigate the challenges of managing corporate work systems

In a group of four to six classmates, identify the case of an information system in use within a work system of a corporate organization. You may find such cases described in computer or business magazines, or through your own work or experiences. It is allowed to use the case of the information system presented in your previous assignment. Look for information about the corporate organization on the Web to gain further insight into the company and prepare a brief description of the business.

Your task is to analyze the role and use of the selected work system within the corporate organization. Take a Work System View on the selected information system, the work system in which it is used, and the corporate organization, and perform the following steps:

1. Review the case and summarize the work system. Produce a Work System Snapshot (see template provided) so that you can answer the following questions:
   a) Identify the main customers of the work system.
   b) Identify the main participants in the system.
   c) Identify the products or services produced by the system.
   d) Summarize the main relevant work practices in the system.
   e) Identify the information used and created by the system.
   f) Identify the technology used by the system.
   g) Identify those aspects of the surrounding environment, strategy and infrastructure that are relevant to the system.
2. Analyze the work system in greater detail, using the Work System Method. Perform an analysis using levels one (headings) and two (questions), and using Steps one (system and problem) and two (analysis and possibilities) of the Work System Method. You will find all relevant instructions and questions to answer in the Work System Method textbook (Alter, 2006b).

Produce a written report detailing your findings. Provide conclusions derived from your analysis. These conclusions may, but do not have to, include recommendations to the organization for further action.

Complement your analysis by an introduction to the case organization and the work system selected, information about the work system method as an approach to describe and analyze information systems in corporate organizations, and an executive summary describing the most important results. Refer to the sample report structure below for guidance.

Sample Report Structure

The following components should be included in the report:

- Declaration by group members
- Cover page
- Executive summary
- Table of contents
- Introduction (purpose of report, signposting etc.)
- Overview of the Work System Method
- Introduction to the selected case
- Work System Snapshot
- Analysis as per Work System Method
- Conclusion
- References
- Appendix: Any relevant further tables, figures, screenshots

Appendix B: Student Report Marking Sheet

Assessment Item	Explanation	Reviewer Comments	Marks available	Marks achieved
Introduction	This part has to provide a well-structured chapter leading into the report. The report has to be motivated by stressing the significance of the topic. An overview about the structure of the report, assumptions, etc. has to be provided.		2	
Background to Work System Method and Case Organization	This part will largely be based on related literature. Provide an overview and introduction of the Work System Approach. Assume that your reader has no knowledge of this approach. Describe objectives and assumptions of the approach. Also provide a short, sharp and concise background to the case organization and the specific business process that is the core of the work system analyzed. Again, expect readers to be unfamiliar with the domain, and write accordingly.		3	
Work System Snapshot	The work system snapshot should be completed using the template provided, and should appropriately summarize the key elements of the work system. The snapshot should allow the reader to quickly identify relevant customers, products/services, work practices, information, technology, participants.		7	
Work System Method	This is the core of the report. Use the headings and questions pertaining to level one and two of the work system method to comprehensively analyze the selected work system. Provide comprehensive answers to all level questions (SP1-5 and AP-10).		10	
Conclusion	The conclusions should summarize the main findings, contextualize the report and also cover any potential limitations. Identify any lessons learnt and derive main ideas from the analysis, so that the question "so what?" can be answered.		3	
Language / Format	The report has to comply to the highest standards in terms of language and grammar. The entire report format should be adequate and well-designed. Figures, tables and appendices should meaningfully complement the text. The constraints are: max. 20 pages, 12pt font size.		2	
Executive Summary, References, Appendix	These sections must complement the core of the report. Is their length appropriate? The executive summary should 'excite' the reader and provide a condensed summary of the main findings (what do we get from this analysis?), not a simple overview about the structure of the report. The references should be relevant and integrated into the core of the report. The appendices must be relevant and consistent.		3	

Biographies

Dr. **Jan Recker** is Alexander-von-Humboldt Fellow and Associate Professor for Information Systems at Queensland University of Technology, Brisbane, Australia. His main areas of research include usage of process design in organizational practice, IT-enabled business transformations and organizational innovation. His research is published in the *MIS Quarterly*, the *Journal of the Association for Information Systems*, *Information Systems*, the *European Journal of Information Systems*, *Information & Management*, the *Scandinavian Journal of Information Systems* and others. He is an Associate Editor for the *Communications of the AIS*, a member of the editorial board of several international journals and serves on the program committee of various conferences.

Steven Alter is Professor of Information Systems at the University of San Francisco. He received his B.S. and Ph.D. at MIT. His research for the last decade has concerned developing systems analysis concepts and methods that can be used by typical business professionals and can support communication with IT professionals. His 2006 book, The Work System Method: Connecting People, Processes, and IT for Business Results, is a distillation and extension of ideas in 1992, 1996, 1999, and 2002 editions of his information system textbook. His articles have been published in *Harvard Business Review*, *Sloan Management Review*, *MIS Quarterly*, *IBM Systems Journal*, *European Journal of Information Systems*, *Decision Support Systems*, *Interfaces*, *Communications of the ACM*, *Communications of the Association for Information Systems*, *CIO Insight*, and many refereed conference proceedings.

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Accelerating Software Development through Agile Practices - A Case Study of a Small-scale, Time-intensive Web Development Project at a College-level IT Competition

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Executive Summary

Agile development has received increasing interest both in industry and academia due to its benefits in developing software quickly, meeting customer needs, and keeping pace with the rapidly changing requirements. However, agile practices and scrum in particular have been mainly tested in mid- to large-size projects. In this paper, we present findings from a case study of agile practices in a small-scale, time-intensive web development project at a college-level IT competition. Based on the observation of the development process, the interview of the project team, and the study of relevant documents, we describe how agile practices, such as daily scrums, backlogs, and sprints, were successfully adopted to the project development. We also describe several supporting activities that the team employed, including cross-leveling of knowledge, socialization, and multiple communication modes. Finally, we discuss the benefits and challenges of implementing agile practices in the case project reported, as well as contribution and limitation of our findings.

Keywords: Agile, Scrum, Software development, Project management, Web application.

Introduction

Created to be a lightweight software development method by 17 software developers at a ski resort a decade ago ("Agile Software Development," 2011), agile development has received increasing interest both in industry and academia due to its benefits in developing software more quickly and at lower costs, meeting customer needs, and keeping pace with the rapidly changing requirements. Agile development aims for customer satisfaction through early and continuous delivery of useful software components developed by an interactive process with the design point that uses minimum requirements. Using agile methods helps refine feasibility and supports the process for getting rapid feedback as functionality is introduced. Developers can adjust as they better clarify unclear requirements. The rate of change in the business world has accelerated dramatically over the past decade. In order to remain competitive, companies developing software need a process that can help them to be more efficient and effective.

Traditional software development methodology such as waterfall is inflexible, expensive, and requires extensive plan-

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ning and rigid adherence to the sequentially based steps in the process (Boehm, 2002). In contrast, agile methods address the challenge of unpredictable and ever-changing needs and requirements in software development and deliver value to users as soon as possible (Nerur & Balijepally, 2007). Table 1 summarizes these differences.

Table 1. Traditional and Agile Perspectives on Software Development
(Nerur & Balijepally, 2007)

	Traditional view	Agile perspective
Design Process	Deliberate and formal, linear sequence of steps, separate formulation and implementation, rule-driven	Emergent, iterative and exploratory, knowing and action inseparable, beyond formal rules
Goal	Optimization	Adaptation, flexibility, responsiveness
Problem-solving process	Selection of the best means to accomplish a given end through well-planned, formalized activities	Learning through experimentation and introspection, constantly reframing the problem and its solution
View of the environment	Stable, predictable	Turbulent, difficult to predict
Type of learning	Single-loop/adaptive	Double-loop/generative
Key characteristics	Control and direction Avoids conflict Formalizes innovation Manager is controller Design precedes implementation	Collaboration and communication; integrates different worldviews Embraces conflict and dialectics Encourages exploration and creativity; opportunistic Manager is facilitator Design and implementation are inseparable and evolve iteratively
Rationality	Technical/functional	Substantial
Theoretical and/or philosophical roots	Logical positivism, scientific method	Action learning, John Dewey's pragmatism, phenomenology

Primary agile practices include:

- Rapid application development (RAD) methodology – RAD methodology emphasizes extensive user involvement in the rapid and evolutionary construction of working prototypes of a system to accelerate the systems development process.
- Extreme Programming (XP) methodology – XP methodology breaks down a project into small phases, and developers cannot continue on to the next phase until the first phase is complete.
- Rational unified process (RUP) methodology – owned by IBM, RUP methodology provides a framework for breaking down the development of software into four gates: Inception, Elaboration, Construction, and Transition. Each gate consists of executable interactions of the software in development. A project stays in a gate until the stakeholders are satisfied, and then moves to the next.

- Scrum methodology - Scrum methodology uses small, self-organizing teams to produce small pieces of deliverable software using sprints (usually 30-day intervals) to achieve an appointed goal, starting with planning and ending with a review. Features to be implemented in the system are registered in a backlog. Then, the product owner decides which backlog items should be developed in the following sprint. Team members coordinate their work in a daily stand-up meeting. One team member, the scrum master, is in charge of solving problems that stop the team from working effectively (Schwaber & Beedle, 2001).

Research Method: Case Study

Case study research is appropriate to investigate a phenomenon in its real-life context and to answer how and why questions (Yin, 2002). Case study method is widely used in Software Engineering and Information Systems (IS) research since it studies contemporary phenomena in its natural context (Runeson & Höst, 2009). This case study examines the value of agile practices in a group-based, small-scale, time-intensive web development project through discovering the following:

1. The particular agile practices adopted by the project team in a small-scale, time-intensive web development project, and the manner in which they were used;
2. Additional supporting activities;
3. Benefits and challenges.

Data were collected using a qualitative, interpretive approach, including observation, interview, and documentation. Team meetings and project development life cycle were observed. Meeting notes, Skype (daily scrum) messages, and project documentation were reviewed and analyzed. Informal interviews were conducted to collect related activities or tasks and further clarify issues.

IT Competition Project Case and Rules

The Information Technology Competition (ITC) hosted by the Management Information Systems Student Association (MISSA) at California State Polytechnic University, Pomona is an annual event where students from California universities and colleges gather to demonstrate and compete their expertise in the Information Technology field. Teams of 3-5 students are given a real-life business project created by a company in the business industry to work on within a two-week time period. Their work is then analyzed, judged, and critiqued by industry professionals. There are five case categories in the competition:

- Business Systems Analysis
- Computer Forensics
- Computer Programming
- Web Applications Development
- Telecommunications

This case study focuses on a web project in the Web Application Development category. Creating the next generation of high-impact, effective web systems requires technical expertise combined with artistic talent. This event encompasses elements of visual design, functionality, usability, creativity, and engineering. This category requires a combined knowledge and skills of both web design and application development. The project assignment is to develop a community oriented web site that allows registered users to submit source code for review by other registered users. The high-level system features and workflow for the web site is illustrated in Figure 1.

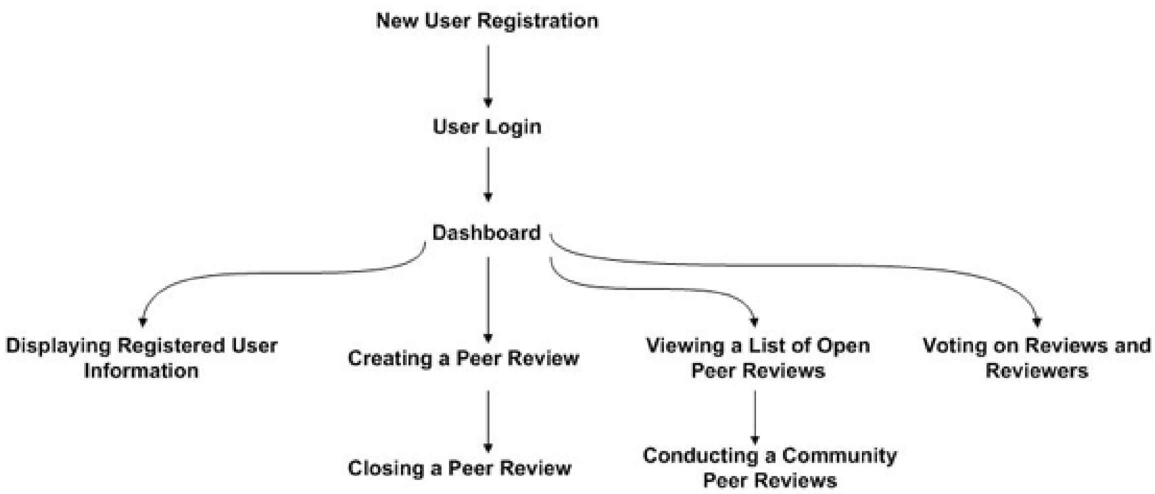

Figure 1. High-level System Features and Workflow

Forming and Structuring Project Team

Team composition in an agile project is usually self-organizing and cross-functional. The project team is self-organizing in that the team leader does not decide which person will do which task or how a problem will be solved; the team as a whole makes such decision instead. The team is cross-functional so that everyone necessary to take a task from idea to implementation is involved. The self-organizing and cross-functional characteristic of agile teams also makes the teams capable of great speed and agility and especially good at socialization and communication. The team is usually supported by two specific individuals or roles: a scrum master and a product owner. The scrum master can be thought of as a project manager for the team, maintaining the processes and helping team members use the scrum framework to perform at their highest level. The product owner represents the business and stakeholders, such as customers or users, and guides the team toward building the right product. In this case study, four students from a California State University majoring in Information Systems volunteered, formed the project team, and represented the university in the competition.

Traditional software development methodologies usually have very specific, laid out development plans. Because of the nature of the team and limited project time frame in this case study, it was not practical for the project team to spend a great deal of time on project management details in advance, such as which team member would develop which aspect of the project; instead, the project team decided to adopt a more flexible approach - agile practices. Scrum, in particular, was used because of its proficiency in developing in small, self-organizing, and cross-functional groups, as well as its best practices for rapid delivery of high-quality software. The formed ITC team self-structured and defined new roles for each member, including a Team Leader, a Database Administrator, a Web Design Specialist, and an Implementation Lead. While these roles are assigned based upon each team member’s assessed strength and expertise, it does not translate to exclusive responsibilities. For example, the team leader also participated in web design and coding, and the database admin also participated in coding and testing, and both contributed to the interface design and documenting. Also, decision-making and task assignment were made via mutual agreement among the team members. The team leader acted as a scrum master, and the competition’s case document writer (an industry professional) served as the product owner.

Implementing Effective Scrum Practices

Daily scrum (via Skype)

Daily scrum meetings are typically held at the same time everyday. During a daily scrum meeting, each team member answered the following questions:

- What have you done today?
- What are you planning to do tomorrow?
- Do you have any problems preventing you from accomplishing your goal?

By focusing on what each member accomplished that day and will accomplish the next day the team gains an excellent understanding of what work has been done, what work remains, and makes commitments to each other. This makes it possible for all members of the team to efficiently gain a perspective of how the system works and to quickly adapt to developing in an area where another team member left off. Traditional methods usually do this using extensive documentation, planning, and rigid work distribution.

The team chose Skype as the daily scrum media because it allowed team members to meet online regardless of their physical location, to easily collaborate via instant messaging, voice, and video conference calls, and to share documents via file transfer - all free of charge. Every day at a specific time (usually 10:30pm) the team met online via Skype for a short period of time (15 - 30 min) and discussed the project status (Figure 2).

Team members usually stayed online after the daily scrum to extend discussion or solve problems together. The team also used Email to clarify questions and answers before and after the daily scrum meeting. In addition, the team held face-to-face meetings once every few days to do in-depth analysis and discussion.

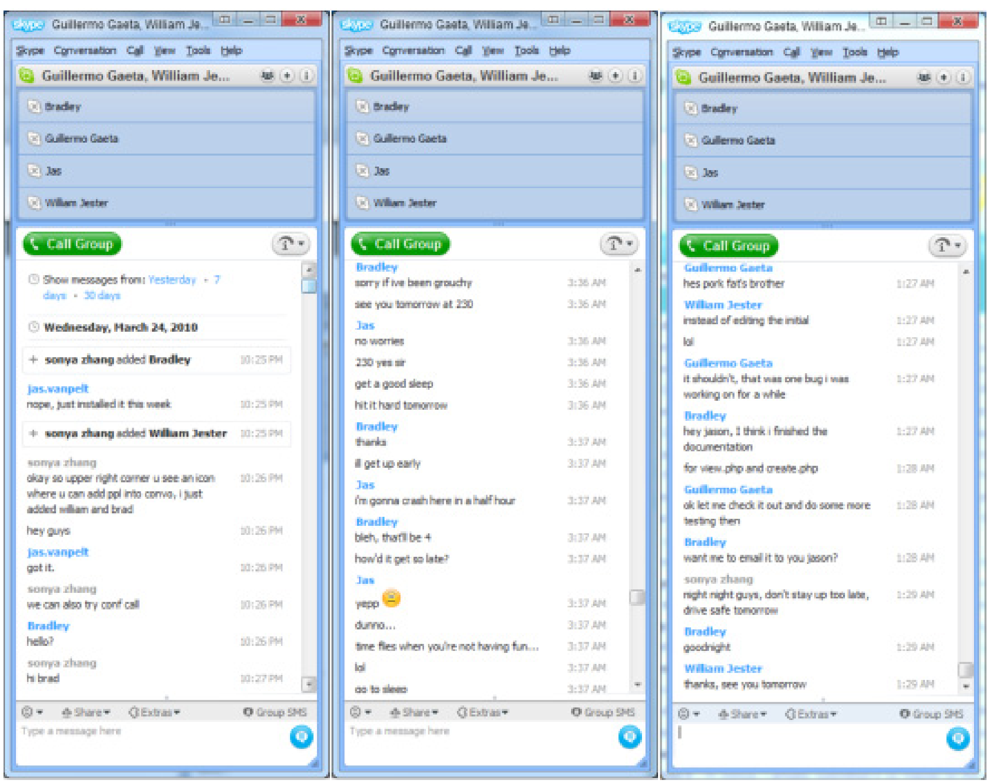

Figure 2. Daily Scrum via Skype

Backlogs

The scrum method uses two types of backlogs to keep a record of the list of work throughout the entire project life cycle. The Product backlog is a high-level, master list of all functionality desired in the working product. Creating a product backlog usually involves the process of transforming user centric specs to technical tasks. The product backlog is allowed to grow and change as more is learned about the product and its customers. In this case study, while the content of the Product backlog and business value of each listed item were derived from the project case requirement document provided by the ITC organizer (written by the product owner) and maintained and updated by the team leader, the associated development effort is set by the team as a whole.

The Sprint Backlogs on the other hand prioritize and expand each Product backlog item into one or more detailed tasks that the team can effectively share and commit to completing within the sprint iteration. In this case study, the project team leader (also the scrum master) maintained the backlog and updated it to reflect the task status and progress (e.g., complete, testing, or implemented). The team added or removed tasks during the iteration when necessary.

Sprints

A sprint is a basic unit in the scrum development methodology and other agile development methodologies. Sprints usually last between one week to one month and are restricted to a specific duration of a constant length. There are usually two types of sprint meetings. Sprint planning

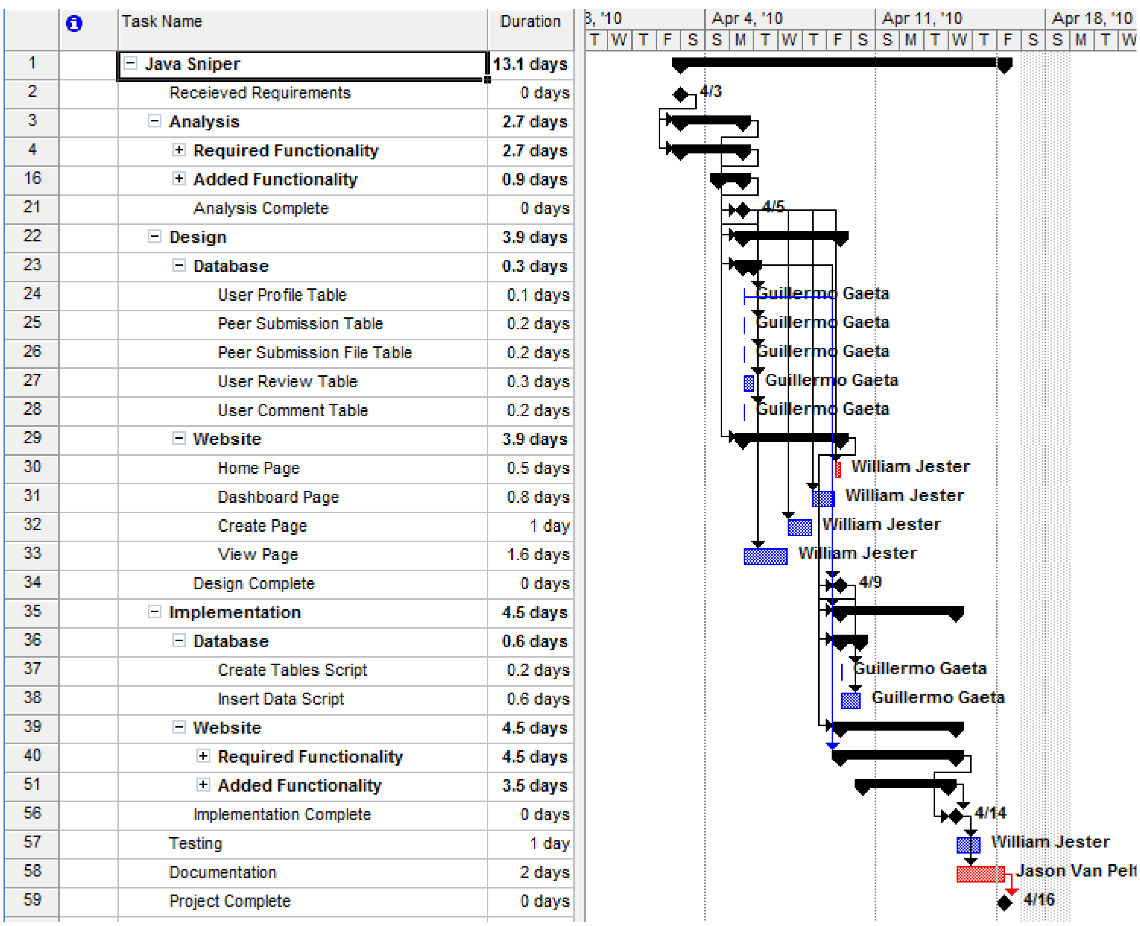

Figure 3. Project Management in a Microsoft Project Gantt chart

meetings are usually held at the beginning of each sprint to decide desired outcome (a commitment to set of features to be developed) in the iteration. A sprint review meeting is usually held after each sprint, when newly developed functionality is presented/demonstrated and reviewed. Modifications are noted and added to the future Sprint backlog.

In this case study, due to the 2-week time constraint for the entire project, each sprint had duration of only 3-5 days. Both sprint planning and review meetings are held via face-to-face meetings. The team also tried to clarify as many issues as possible via Email before the meeting to keep it short and concise.

The team used Microsoft Project as the project management tool to maintain the sprint backlogs and to facilitate sprint planning, monitoring, and reviewing. A common project management tool provided by Microsoft Project is the Gantt chart. A Gantt chart is a simple bar chart that depicts project tasks against a calendar. On a Gantt chart, tasks are listed vertically and the project's time frame is listed horizontally. A Gantt chart works well for representing the project schedule. It also shows actual progress of tasks against the planned duration. Figure 3 shows the project management using a Gantt chart.

As shown in the Gantt chart in Figure 3, the team divided the project into 3 sprints:

Analysis Sprint - In the analysis sprint, the team applied Use case (user centric specs in product backlog) to describe system behavior from an actor's point of view as scenario-driven threads through the functional requirements. Figure 4 shows an example of the Use case for the scenario where a user comments on a post.

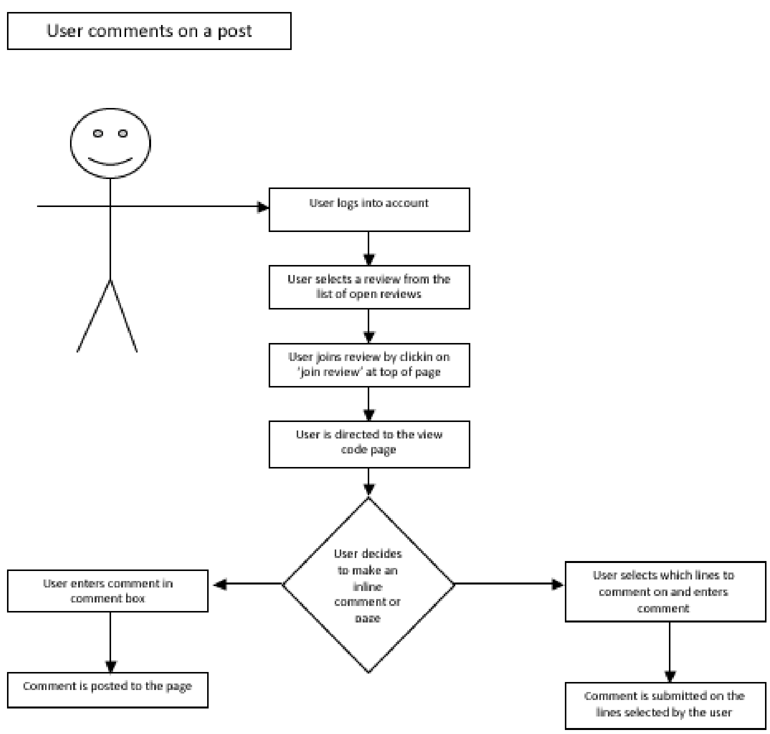

Figure 4. Use Case for a User Comments on a Post

Design Sprint - The design sprint includes database design and web interface design. The database design (technical tasks in product backlog) in this sprint is mainly a conceptual design. The process includes creating the data requirement document (i.e., describe what data items will be stored in the database and how the various data items relate to one another), analysis (i.e., define detailed attributes of the data and constraints), and constructing ERD (conceptual data model) and

Data dictionary (logical schema). After the database was structured, the web interface was prototyped and designed to coordinate the functionalities and tasks specified in the sprint backlog, also to be understandable, intuitive, and simple to users. Figure 5 shows the Entity-Relationship Diagram for the project.

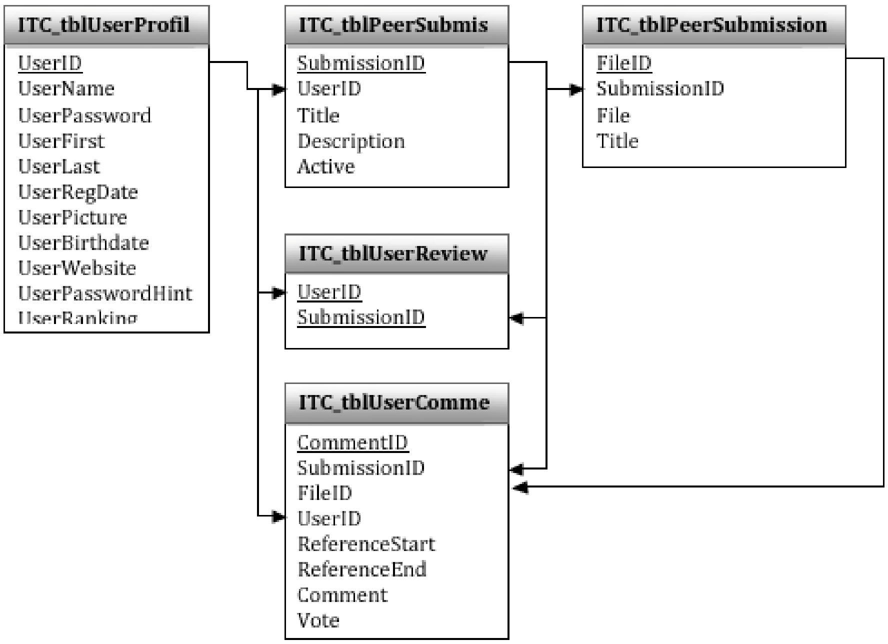

Figure 5. Entity-Relationship Diagram

Implementation Sprint - The implementation sprint includes database implementation and functionality implementation. The database implementation was accomplished using SQL statements. The process includes implementing the database (e.g., create database, set users and privileges, create tables, set constraints, etc.), populating each table with specific data (e.g., configuration and testing data), and optimizing the database structure and performance (e.g., normalize, index, cache, monitor). After the database was implemented and populated with data, functionalities shown in Figure 1 (High-level System Features and Workflow) were coded, tested, and implemented.

In this case study, the software product (called “Java Sniper” because it provides community-based review service for source codes written in Java) was developed using an open source LAMP (Linux, Apache, MySQL, and PHP) environment. The base user interface, dynamic page contents, and reusable functions of Java Sniper were created using HTML, CSS, Javacript, AJAX, and PHP with Adobe Dreamweaver CS4 and Adobe Photoshop CS4. The data is stored in a MySQL database and accessed via embedded SQL within PHP pages. The working product is cross-platform – it can be hosted on various operating systems including Linux and Windows, it can also be implemented in various web servers including Apache and Microsoft IIS. Users can access the web site via various web browsers, including IE, Firefox, and Safari. Figure 6 shows the system architecture.

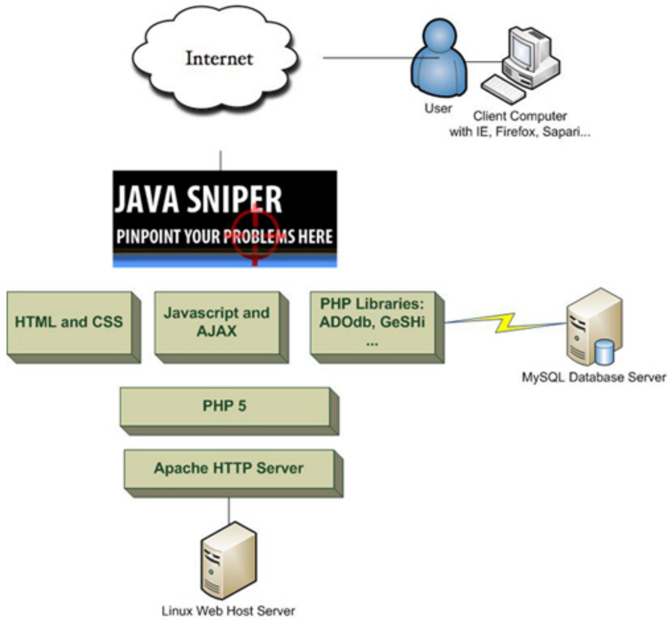

Figure 6. System Architecture

Supporting Activities

In addition to the common scrum practices, the team also employed several supporting activities:

Cross-leveling of knowledge

As opposed to a traditional development team, a scrum team is by nature self-organizing and cross-functional. Although different roles are assigned based upon the team member's strength and expertise, each member acts as a middle manager to bridge the difference between the theory (what ought to be) and the reality (what can be done) to each other. They translate theory into practical requirements, which are then tested in the reality. Any contradiction is communicated and resolved. In this case study, team members shared knowledge and skills in web design and development, database design and management, and other relevant areas to help each other accomplish the tasks.

Socialization

The effects of socialization depend upon the team members' interpersonal skills, trust, and interaction with each other. In this case study, all team members came from the same class, therefore they were somewhat familiar with each other before the project began. However, none of the team members had any sort of social or professional relationship with any of the other team members prior to the start of the course. The team members did not interact with one another specifically, though they were familiar with each other's appearance and course work. These relationships are a good representative for team members that do not face significant cultural or communicative barriers but have not worked together before.

Throughout the project, the team members got to know each other more and became friends. In addition to working on the project together, they also shared common values and interests as college students. The team commented that the establishment of successful and satisfying relationship during socialization helped improving collaboration and productivity.

Multiple communication modes

In agile practices, usually several different kinds of communication are available that can also be applied in parallel, i.e., individual and conference telephone, teleconference, videoconference, email, instant messaging, blog, wiki, and desktop sharing. In this case study, the team utilized multiple communication channels including face-to-face meetings, Email, Skype-supported instant messaging and teleconference, and file transfer.

The team recognized the importance of the fact that each communication avenue provided a valuable way for the team to exchange information. Each communication avenue had its strong points, and weak points. For example, though face-to-face communication can convey many ideas quickly, it is ineffective when describing code, syntax, or sharing files.

Specifically, the team pointed out that face-to-face meetings helped the team to focus on the discussion without other disruptions and also provided more information in terms of body language, subtle personality and demeanor, and lively exchange of ideas or conversation; while online communications such as Skype meetings provided more flexibility including meeting late night or geographically separated, looking up information online, or sharing important files and documents while chatting. Email and chatting was the least invasive and most flexible, but was usually not as effective as other methods. Therefore, both communication channels facilitated teamwork in various aspects.

Discussion

The project team successfully delivered a working software product (i.e., Java Sniper) at the end of the 2-week time frame. The team demonstrated the final product to the judges (industry professionals) and won second place in the web development category.

The team also compared the efficiency of Java Sniper with other popular code review systems on the market (e.g., Codestriker and Reviewboard) by conducting three different types of testing – installation, code submission, and code review tests. The installation test involved creating a database, installing and configuring scripts, modules, and libraries, and getting the system up and running. The code submission test involved navigating to the submission page, loading the page, filling in the information required, and submitting four files containing Java source code designed to output the text "Hello World!" for review. The code review test involved accessing the submitted files, reading through it (the files were all very small and reading time was almost negligible), and writing and submitting the review (time for writing review was recorded separately because writing time should be independent of all three systems). The testing results (Table 2) show that Java Sniper is the most efficient of all three systems in terms of installation, code submission, and code review.

Table 2. Efficiency Testing

Code Review Software	Language	Installation Test	Code Submission Test	Code Review Test (writing time excluded)	Allow submitting multiple source files as one project
Codestriker	Python	45 min	12 min 20 sec	5 min 32 sec	No
Reviewboard	Perl	20 min	2 min 58 sec	2 min 4 sec	No
Java Sniper	PHP	15 min	47 sec	35 sec	Yes

During both project presentation and interview, the team affirmed that the agile practices employed were a critical success factor for them to achieve the goal of developing a good quality software product that satisfied the case requirements within limited time frame; the product would have been completed with fewer features or less quality otherwise. The team stated that the agile practices benefited the project in the following aspects:

Increased quality of the deliverables

Agile technologies feature more frequent delivery of smaller, valuable increments and build quality in rather than add it in at the end of the project. Because of the strict time and scope limit, quality is more easily monitored, managed, and achieved by the end of the iteration. In this case study, team members often reminded each other during daily scrums and sprint meetings to stay on track, prioritize, and focus on the main features specified in the requirement document. As the result, the team was able to deliver a satisfying software product within the limited time frame.

Better change management

A project's requirements will change at some point of time. In scrum, change is embraced and new requirements will be evaluated against existing ones when planning the next sprint. The business and product owner are actively involved in this process, making sure the delivered features are actually useful and valuable to end users and business. Even though in this case study, the project requirements were mostly defined in the case document in advance, during the analysis sprint the team still found some issues that were unclear, such as the expectation of utilizing open source components and services and the weight of additional features that is not explicitly specified in the case document. After clarifying these issues with the case writer the team quickly changed the technical specs accordingly before moving into the design sprint.

More efficient workflow

By using short iterations (i.e., daily scrum and sprints), the team was able to calculate/estimate the time and resources needed and track the development progress for each task in a clearer and more accurate way. As the result, the team was able to be more in control of the project schedule and status and work more efficiently. In this case study, the team used Microsoft Project to plan and manage the time and resources needed for each critical project task and made sure that the tasks were accomplished by the end of the assigned iteration.

Increased innovation

Whenever a new and innovative idea was discovered, the team could quickly share and communicate with the business and production owner and possibly build it straight into the next sprint. In this case study, when the team found out that open source components and services were encouraged in the analysis sprint, they decided to implement an open source tool called GeSHi (Generic Syntax Highlighter) to process each source code file when it was submitted for review and then saved in the database to be displayed on the Source Code Viewing page later in different colors and fonts according to the programming syntax. This feature provides the reviewers with a consistent code formatting and/or syntax highlighting and helps them better recognize problem points in the code. And because the tool was open source, the team saved significant time and effort compared to developing it from scratch.

Like any other agile practitioner, the team in this case study also encountered several challenges. Because the size of the team was fairly small and all the members were college students, the daily scrum or sprint meetings were informal and often involved a lot of socialization. Also because the team members were amateur in software development, they spent a lot of time collaborating and helping each other in cross-functional problem solving. These challenges may be less significant in the teams consisting of professional software engineers/developers; however, other challenges may present, such as recruitment of agile staff, training, motivation, performance evaluation, communications, adapting agile for distributed teams (different culture, background, language, time zone, etc.) and large-scale enterprise projects (more complicated technical specs and rapidly changing requirements).

Conclusion

This paper presents findings from a case study on agile practices in a small-scale, time-intensive web development project at a college-level IT competition. Based on the observation of the development process, the interview of project team members, and the study of relevant documents, we describe how agile practices, such as daily scrums, backlogs, and sprints, were successfully applied to the project development. We also describe several supporting activities that the team employed, including cross leveling of knowledge, socialization, and multiple communication modes. Finally, we discuss the benefits and challenges of implementing agile practices in the case project reported. Our study found that agile practices were a success in this case study, which confirms that agile methodology is suitable for voluntary, self-organized, cross-functional teams developing small-scale, time-intensive software development projects.

Case studies in software engineering and information systems research often test theories and collect data through observation of a project and other qualitative methods such as interview and documentation. Each team and project characteristics are unique to each case study; thus comparisons and generalizations of case study results are difficult and are subject to questions of external validity (Kitchenham, et al., 2002). The Java Sniper project described in this case study is a reasonable representative of a class of small-scale, time-intensive software development projects in computer science or software engineering courses (with similar number of developers, developers' background and experience, time, and project scope). However, such group projects can still differ in terms of size (software requirements, the number of lines of code), design pattern, type of software developed, language used, etc. It would be interesting to analyze the degree to which agile practices in projects that differ along these dimensions resemble the findings of this case study.

References

Agile Software Development. (2011). *Wikipedia.* Retrieved August 26, 2011, from Wikipedia: http://en.wikipedia.org/wiki/Agile_software_development

Boehm, B. (2002). Get Ready for Agile Methods, with Care. *Journal Computer , 35* (1), 64-69.

Kitchenham, B. A., Pfleeger, S. L., Pickard, L. M., Jones, P. W., Hoaglin, D. C., Emam, K. E., et al. (2002). Preliminary Guidelines for Empirical Research in Software Engineering. *IEEE Transactions on Software Engineering , 28* (8), 721-734.

Nerur, S., & Balijepally, V. (2007, March). Theoretical reflections on agile development methodologies. *Communications of the ACM , 50* (3).

Runeson, P., & Höst, M. (2009). Guidelines for conducting and reporting case study research in software engineering. *Journal of Empirical Software Engineering , 14* (2), 131-164.

Schwaber, K., & Beedle, M. (2001). *Agile Software Development with Scrum.* Prentice Hall.

Yin, R. K. (2002). *Case study research, design and methods.* Sage Publications.

Biographies

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A Critical Analysis of Active Learning and an Alternative Pedagogical Framework for Introductory Information Systems Courses

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Executive Summary

Active learning has been championed in academic circles as the pedagogical fix to boring lectures typically found in introduction to information systems courses. However, the literature on active learning is mixed. In this paper, we critically examine active learning research and discover a misplaced emphasis leading to paradoxical findings in four areas. First, creating activities for cognitive engagement is not unique to active learning. Second, the amount of instructor led control and direction is often glossed over, leaving a vague impression as to how much is necessary. Third, out of class activities are often ignored when they also accomplish the same effects for the same reasons. Fourth, an over-emphasis on techniques rather than outcomes renders active learning bound to means and not to ends. The proper end should be the meaningful learning of the course objectives.

We offer an alternative pedagogical framework for evaluating classroom techniques based on philosophic, psychological, and pedagogical research. Ausubel's Assimilation Learning Theory fits this research with a focus on meaningful learning of classroom objectives. In order to achieve meaningful learning of new concepts, an instructor must accomplish four things: (1) clearly define the concepts, (2) provide proto-typical examples, (3) integrate the concepts within the students' knowledge, and (4) motivate the students to want to learn. Application of this pedagogical framework to introductory information systems classes provides a basis for evaluating classroom techniques and increasing meaningful learning. Turning the theory into practice, we propose three different ways to teach a Decision Support System module within an information systems course. Each approach is consistent with the meaningful learning framework. Those three approaches include the traditional lecture format, an activity based format consistent with active learning, and a case study based format which serves as a hybrid between passive and active learning techniques. For each approach, we highlight how the class structure, examples, and resources can help instructors create a meaningful learning experience for their students.

Keywords: meaningful learning, active learning, introduction to information systems, decision support systems, assimilation learning theory

Introduction

Active learning – loosely defined as instructional methods that place the responsibility of learning on learners – has gained considerable attention in higher

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education (Prince, 2004), particularly within business programs (Auster & Wylie, 2006; Heriot, Cook, Jones, & Simpson, 2008). Heralded as a means of helping students become engaged in the learning process, it promises to create classroom environments where students can not only obtain knowledge but also apply that knowledge in ways similar to those they will face in their career. This pedagogical technique is accomplished through talking, reading, writing, and reflection. Active learning contrasts with passive learning, which typically involves traditional lecture formats or reading assignments. Passive learning continues to be a mainstay in many Introduction to Information System (IIS) classes (Pridmore, Bradley, & Mehta, 2010). Traditional lecture format often challenges students' attention span, resulting in a rapid drop-off in the retention of class topics (Hartley & Davies, 1978; Wankat, 2002). Given the promises for active learning, it seems natural that we should consider its application to IIS courses.

However, little research shows the application of active learning to IIS courses. As a required course for most undergraduate business majors, this may be the only introduction business students receive to information system concepts. Many students enter college with little understanding or appreciation of information technology (Ballou & Huguenard, 2008), yet they are required to use them extensively upon entering the work force. The challenges of presenting information technology content effectively are anything but trivial. With technological change accelerating at an exponential rate, much of what students learn will be obsolete by the time they graduate from their programs. Compounded with the rate of change is the frequent lack of interest in information systems (Ballou & Huguenard, 2008). This results in frustration for the instructor to teach a subject well, along with a frustration from the student in learning disconnected facts. Given these problems, it is reasonable to ask if active learning is an appropriate means of improving IIS instruction.

In this paper, we examine the application of active learning to IIS courses. By examining philosophical, psychological, and education-based literature, we challenge the active learning pedagogical framework and suggest an alternative framework would be more effective at presenting content in IIS courses. The criteria for a successful framework are that it is universal to all contexts, it is self-contained, and it is consistent with epistemological and psychological facts. Our objective is threefold: (1) to critically analyze active learning techniques, (2) to explore how and why these techniques succeed or fail in producing meaningful learning of IIS concepts, and (3) to provide an example of Assimilation Learning Theory (ALT) to a Decision Support Systems (DSS) module within an IIS course.

In the next section, we review active learning research, identify its limitations, and suggest a new approach based on epistemological and psychological foundations necessary to support meaningful learning. Based on this foundation, we discuss implications in IIS courses and provide example implementation.

Background

Many credit educational philosopher Dewey (1959), with his learning by "doing" philosophy, and child psychologist Piaget (Gallagher & Reid, 2002), with his "active" approach to learning, for laying the theoretical foundation of the active learning movement. Unfortunately, active learning has a history of vague definitions and nebulous descriptions that make discussion of this concept difficult (Bonwell & Eison, 1991; Prince, 2004). Examples of active learning include in-class discussion, case study discussion, short written exercises, role-playing, games, hands-on activities, debate, academic service learning, experimental learning, and discovery learning. Classroom activities that generally fall into the passive learning category include lectures, reading textbooks, and traditional homework. In a much cited U.S. government report (Bonwell & Eison, 1991), the following themes were identified in active learning education: (1) students are involved in more than listening, (2) less emphasis is placed on transmitting information and more on developing students' skills, (3) students are involved in higher-order thinking (analysis, synthesis, and evaluation), (4) students are engaged in activities (reading, discussing, or writing), and (5) greater emphasis is placed on students' exploration of their own attitudes and values. These trends led Bonwell and Eison (1991) to define active learning as activities that "involve students in doing things and thinking about the things they are doing." Because this government report is very influential in funding educational and pedagogical research projects, it serves as the starting point of our analysis.

There are several problems with this conception of active learning. We will address four. First, what does it mean to involve students in "doing" things? Does "doing" something require physical activity? There is evidence that *physical* activity may be harmful to learning concepts (Mayer, 2004), suggesting that activity in and of itself does not support learning. It must be well designed *cognitive* activities that promote thoughtful engagement around learning outcomes (Mayer, 2004). Yet, there is nothing inherent in typical active learning activities that suggest they alone provide thoughtful engagement. Some so called passive learning activities can promote thoughtful engagement. Many of us remember instances of thought provoking lectures or spell binding books. Such "passive" activities keep audiences cognitively engaged for long periods when structured appropriately. Books on study methods suggest students can improve their active engagement during lectures to help improve retention (Locke, 2008). If this is in fact true, then passive learning can cause thoughtful engagement if students are properly motivated and skilled at thinking while taking notes. There is no evidence that all active learning activities provide thoughtful engagement. While it may be a goal of some activities, the framework does not distinguish between activities that do and those that do not.

A second problem with the above conception is that it leaves unanswered how much control and guidance the instructor should have in the class. At the extreme in pure active learning, sometimes referred to as inquiry learning, the instructor involvement is minimal to non-existent. In one such pure active learning, called discovery learning, students engage with materials without any instructor support, guidance, or influence. Research efforts found that discovery learning is inferior to guided learning in gaining knowledge about the subject (Kirschner, Sweller, & Clark, 2006; Mayer, 2004). Considering that discovery learning is asking students to discover principles inductively that experts in the field struggled years to discover, the struggle to gain knowledge makes sense. Interestingly, in a widely cited government policy statement noted above, no pure active learning research was included. In cases where active learning shows improved student retention of class materials, the instructor still provided a lecture and guided the activities (Astin, 1993; Di Vesta & Smith, 1979; Hake, 1998; Ruhl, Hughes, & Schloss, 1987). Therefore, the notion that some active learning is beneficial may stand, but more may not be better. Unfortunately, active learning proponents do not provide a means of evaluating how much guided instruction is ideal or necessary.

Third, many active learning proponents do not consider engaging out-of-class activities as part of the active learning tradition (Bonwell & Eison, 1991; Prince, 2004). Given the definition of active learning above, there is little justification for this exception. Challenging homework problems, online discussion boards, or written assignments can provide the same benefits of in-class activities. In each case, students engage in higher order thinking activities in order to develop skills, reflect on their experiences, or think about class discussions. These activities generally promote thoughtful engagement around learning outcomes.

Lastly, there is a focus on techniques for instruction, rather than outcomes. Although active learning proponents may strongly counter such a claim by asserting that active learning does include higher order thinking and reflection, too often they do not specify to what end. Collaboration and cooperation work only if students do not fumble with new concepts and principles. Classroom discussions may not be helpful if misconceptions continue unchecked and propagate into later discussions. Active learning proponents may claim to support learning objectives, but the discussion always focuses on the dichotomy between active and passive techniques. Without a clear focus on the ends, well-meaning instructors may mis-apply techniques in the classroom. Active learning provides no standard for judging the appropriateness of one technique over another.

To unravel these paradoxes, it is necessary to dig deeper into the causes of successes and failures in learning and understanding concepts. Why is active learning effective in certain contexts but not in others? Why are some lectures engaging and others boring? Is there some common denominator to explain success or failure in teaching concepts? In the next section, we explore the epistemological and psychological foundations of concepts, conceptual development, and pedagogy. From this, we propose an alternative framework for evaluating classroom techniques in IIS and provide three examples of this framework applied to a Decision Support System module within an IIS course.

Epistemological and Psychological Foundation of Concepts

From an early age, children develop an understanding of the world. This process starts with recognition of patterns from their perceptions. Similarities and differences between characteristics of real world objects evolve into ever more complex identifications. Concepts are formed when specific essential characteristics are subsumed into a single mental unit with an attached word (Rand, 1990). By forming concepts, individuals create mental groupings that economize their thinking process such that they can think about hundreds or thousands of specific entities without having to keep them all in mind at the same time. By thinking the concept "computer", an individual *integrates* references to the millions of computers in the world without having to keep all of them in his short-term memory at the same time. Without the economizing nature of concepts, an individual would have to try to include all possible variations of a concept in his mind at the same time, an impossible feat given the limitations of our working memory (Cowan, 2001) and the diversity of objects in the world.

A hierarchy of concepts emerges. Simple concepts closely related to perceptions of objects and relationships in the real world form the bottom, and complex concepts dealing with abstract generalizations form the top. In biology, the hierarchy of concepts explicitly categorizes every living thing using the taxonomy species, genus, family, order, class, phylum, and kingdom. Each successive level in the taxonomy includes a larger number of specific real world life forms, encapsulating concepts that are more abstract. Biology also recognizes a number of concepts for relationships between life forms, such as simple predator-prey relationships, to more complex parasitic and symbiotic relationships, to very complex ecosystem relationships. The same hierarchy exists in every domain of knowledge.

As individuals mature, conceptual understanding of reality develops with more precise definitions, better understanding of relationships between concepts, and finer differentiation of subconcepts. The role of education is to facilitate this growth in conceptual understanding. As learners move from novice to expert, they learn new concepts, establish more relationships between concepts, and identify more examples of concepts. Meaningful long-term learning only takes place when concepts introduced build upon the knowledge base already established (Novak, 2002). Understanding a domain of knowledge requires the integration of new concepts within their entire semantic network (Regehr & Norman, 1996). Without this integration, ideas are quickly forgotten and of little use to the learner in future applications.

An Alternative Pedagogical Framework

An alternative pedagogical framework empirically shows large improvements in long-term meaningful learning. This approach identifies a continuum from meaningful learning to rote learning, first identified by educational psychologist Ausubel (1968) in his Assimilation Learning Theory (ALT) and enhanced by Novak (2010). According to Ausubel, there are four things necessary for meaningful learning: (1) new concepts are carefully defined, (2) new concepts are related to real world examples, (3) new concepts are integrated with the learner's prior knowledge, and (4) new concepts are motivating to the learner (Novak & Cañas, 2008). Meaningful learning requires well-organized relevant examples and an emotional commitment by the learner to integrate new knowledge. Students must want to, be able to, and be shown the relevant material to learn course objectives by integrating material into existing concepts, progressively differentiating concepts into sub-concepts, and creating new superordinate concepts (Novak, 2010). Meaningful learning fails when students are not properly motivated, when definitions are unclear or ambiguous, when insufficient or irrelevant examples are shown, or when concepts are not integrated with students' current knowledge. In rote learning, the learner memorizes a conceptual definition and does not or cannot apply it to their prior knowledge. Rote learning often results from little or no relevant knowledge or examples from which to base understanding and from no emotional commitment for integration (Novak & Cañas, 2008). Such rote learning can be retained in memory long enough to pass an exam, but because it is not integrated with existing knowledge it is soon forgotten.

While the meaningful/rote learning differentiation focuses on the transmission of knowledge from instructor to student, ALT is much broader. Figure 1 highlights our understanding of this theory. All learning materials should start with an assessment of prior knowledge of the students. Ausubel (1968) states the most important factor impacting learning is what the learner already knows. With an assessment of learner's prior knowledge, the instructor can construct the learning environment and materials that build on what the students already know and understand, thereby limiting repeat materials while avoiding unwarranted assumptions of prior understanding. This assessment should be ongoing throughout the class. The instructor should not assume that just because the material was presented that the learner understands it. If the instructor proceeds to new material without verifying the conceptual understanding of earlier concepts, it becomes increasingly difficult for the learners to understand the new concepts when those new concepts are based on preceding ones.

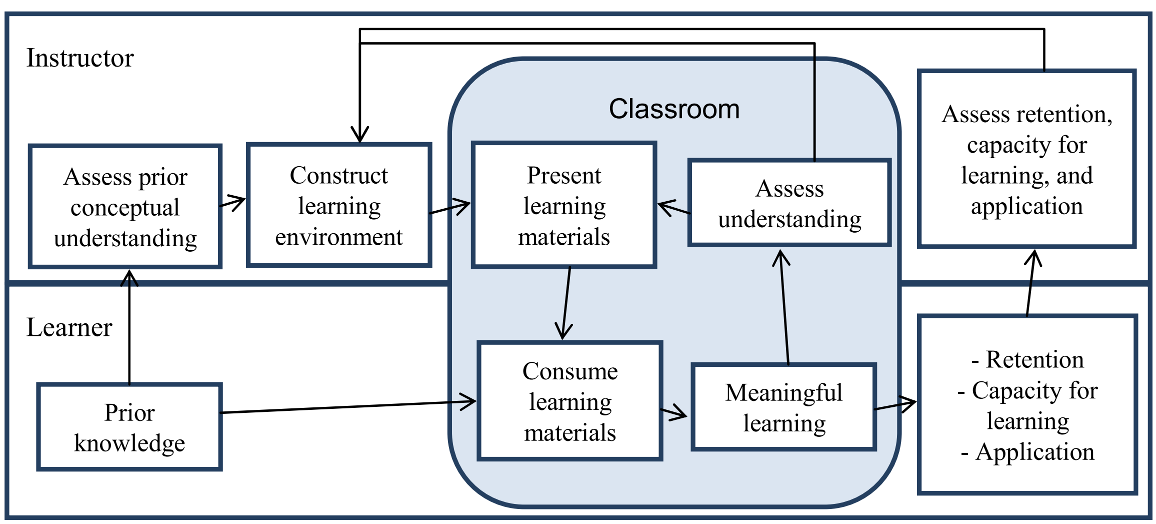

Figure 1. Our understanding of ALT

Assessing rote learning versus meaningful learning can be difficult during the class. The ultimate assessment of meaningful learning is (1) the long-term retention of concepts,(2) differentiability of related materials, (3) capacity to learn unrelated subjects, and (4) application to new problems and contexts (Novak, 2010). Post-hoc assessment provides a means to evaluate the original learning environment for possible improvements. Because of the complexity of this framework, we focus on the presentation of learning materials and its four prerequisites to meaningful learning: definitions, examples, integration, and motivation.

Implications

Active learning in education provides some benefits to conceptual development, but only to the extent it facilitates meaningful learning. Active learning techniques should be considered as part of a toolbox that can help facilitate mastery of materials, but only if used appropriately. When comparing active/passive learning to meaningful/rote learning, we can envision them as orthogonal, such that active learning can be meaningful or rote just as passive learning can be meaningful or rote. Below, we discuss the application of this framework and the four assessment criteria for meaningful learning to an IIS context.

The first place IIS instructors and researchers should focus is discovering what incoming students already know. To the best of our knowledge, little research exists on student knowledge of information systems before entering an IIS course. We should not assume students are familiar with many of the technologies discussed in a particular course module. In order to relate discussion to new technologies and theories, discussion should start with everyday contexts familiar to students. These might be common problems they face, real-life dilemmas they can relate to, or tools they currently use to achieve their goals. By starting at these points, instructors can simultaneously motivate, integrate, and identify examples. The motivation comes from identifying a problem in their lives that needs attention. Integration comes from relating their personal problems with technology that can fix those problems. The examples are identified by the students themselves, although the instructor may add additional examples to deepen the discussion further.

Because motivation is major issue in IIS (Ballou & Huguenard, 2008), students must be presented with a convincing immediate need that IS can help resolve. The lack of interest in IS stems, in part, from a lack of understanding of the relevance of the subject to their current and long-term success. Students, who have grown up with computers, take them for granted. Unless the instructor can effectively demonstrate the need, students may struggle to identify that purpose for themselves. Techniques, such as problem based instruction, have shown some success in increasing motivation for IS concepts (Mykytyn, Pearson, Paul, & Mykytyn, 2008).

IIS instructors and researchers should build each course module upon prior work. While a systematic development of skills and knowledge over time is often acknowledged in MIS programs (Harper & Harder, 2009), a means of identifying the proper order is too often neglected. Likewise, the sequence of course modules in IIS should systematically develop knowledge of IS concepts over time. Instructors have several optional approaches to sequencing modules. One method would be to start with abstract concepts and progressively differentiate sub-concepts. For example, they could start discussing the general concept “computer”, which leads to a discussion of the different types of computers used for different, specialized purposes. Another method is to start with less abstract concepts close to concretes and successively introduce more abstract concepts. Here, instructors might start the semester by presenting information system successes and failures in order to establish basic principles for information systems success.

However, abstract and complex subjects should be covered after simple subjects are meaningfully learned. If explaining networks, discussion should start with simple home networks or build on the students’ understanding of the internet. If discussing enterprise resource planning, examples could start with point of sales systems, which most students can relate to at least indirectly when they purchase items from stores. A discussion of IT architecture or IT strategy is beyond the understanding of most students entering an introduction to IS class, as few have worked extensively with computers in an organizational context or had a class in business strategy. Including a discussion of strategy early in an introductory IS course would be far too difficult for many learners to apply to their previous knowledge. Prior to learning about IT strategy, students should meaningfully learn about computers, data processing, infrastructure, and the need for long-term IT planning from which to build a rich and meaningful understanding of why IT strategy is important for continued innovative success.

In establishing the proper order of conceptual coverage, ALT suggests that simple concepts precede complex concepts. Unfortunately, this is too often neglected (VanDamme, 2006). Determining which concepts are simple and which are complex stems from the historical fact that simpler concepts are discovered prior to complex concepts. There is a necessary precondition that all complex concepts necessitate the discovery of simple concepts first. In mathematics, the discovery of algebra preceded the discovery of calculus. It would have been impossible for Newton or Leibniz to create calculus if algebra was unknown by these men. As mathematics educators can relate, it is impossible for students to meaningfully learn calculus without first having mastered algebra. This same approach can be used for identifying the order of conceptual coverage in class.

For example, there were large scale accounting machines in businesses prior to computers. These accounting machines handled business problems requiring massive number crunching. However, accounting machines lacked the flexibility to handle the increasingly diverse types of calculations required by large businesses. The ability to program computers gave them an advantage over traditional accounting machines by allowing for flexibility in usage. This historic fact suggests that data processing needs of businesses should be discussed prior to discussing computers and their functionality.

History will not provide all the answers to content inclusion or ordering of conceptual discussions. Some historical events have little influence on subsequent events. Discussing such events in the curriculum does not help students build meaningful understanding of concepts. Additionally, there will likely be some optional ordering schemes when concepts are completely independent or partially interdependent and arising simultaneously. There will also be cases where names of concepts have changed over the years, such as the term computer, which originally referred to people who computed numbers but now refers exclusively to a specific electronic technology. Our role as educators is to pull all of this information together, determine what is relevant, organize it, and present it in a context appropriate for meaningful learning.

Theory into Practice

One area where many IIS textbooks have inadequate concept development is in DSS (Hassan & Becker, 2007). Given the limitation of the textbooks, the in-class experience is especially critical for conceptual understanding. DSS includes a variety of tools, including model-driven, data-driven, document-driven, rule-driven, and communication-driven applications (Power & Sharda, 2009). Applying the meaningful learning framework suggests that the class module should (1) define the terms clearly, (2) integrate the concepts within the student conceptual framework, (3) provide prototypical examples, and (4) motivate the learner. Defining the terms clearly is often not an issue and can be done in conjunction with describing the broad categories. For example, Power and Sharda (2009) define the 5 categories as:

- "Model-driven DSS emphasize access to and manipulation of a model." (p. 1542)
- "Data-driven DSS emphasize access to and manipulation of a large database of structured data, especially a static time-series of internal company data and, in some systems, external data." (p. 1542)
- "A Document-driven DSS integrates a variety of storage and processing technologies to provide complete document retrieval and analysis." (p. 1542)
- "Rule-driven DSS can suggest or recommend actions to decision makers." (p. 1543)
- Communication-driven DSS "includes communication and collaboration decision support technologies that do not fit conveniently within three DSS types…" (p. 1543)

How and when these definitions are presented will depend on the context of the class. We provide three possible approaches to teaching this module within the meaningful learning framework; one using traditional lecture techniques, one using active learning techniques, and one using case study analysis. All three approaches follow the basic course learning goals and order of coverage (Figure 2). First, students must be motivated by seeing real world decision making problems. Then, they must see that there are activities that can be done to overcome these limitations. Lastly, they must see that a technological solution exists and what that solution is called.

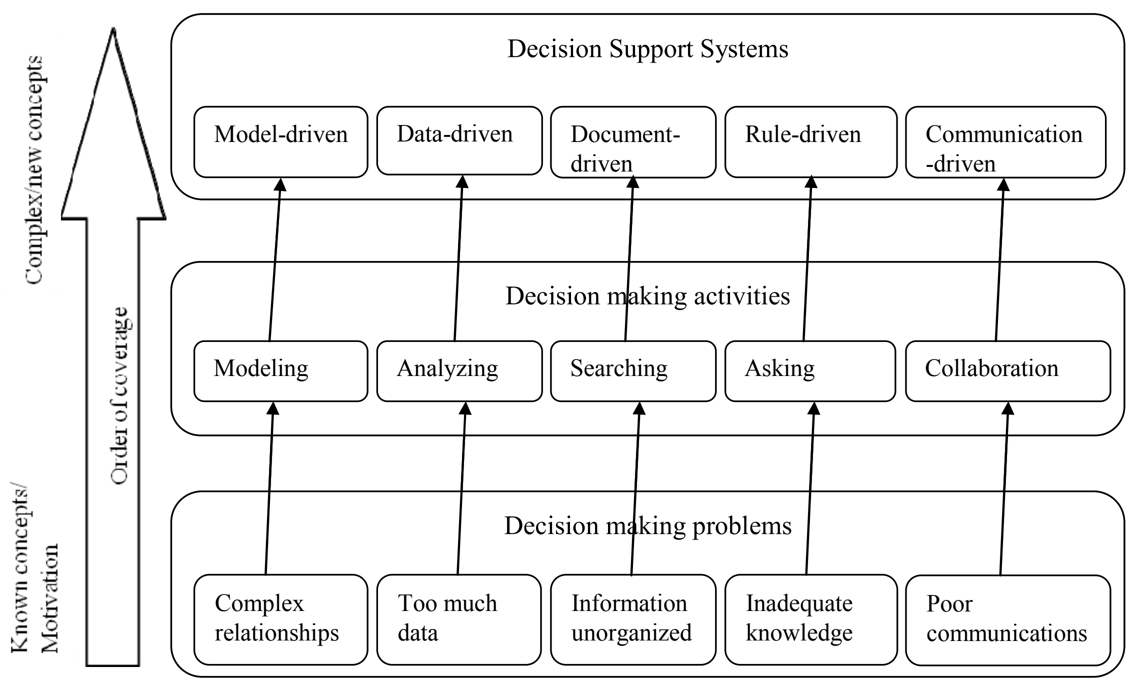

Figure 2. DSS Module learning goals and order of coverage

Example 1. Traditional Lecture Approach

While lectures excel at delineating definitions, providing examples, and having a large capacity for integrating concepts, the danger is that students are not motivated and quickly lose interest. One technique to motivate students during lectures is with story-telling (Buckler & Zien, 1996). The instructor can introduce the lecture with a series of short stories demonstrating the cognitive limitations of humans in five different contexts. In keeping with ALT, these stories should relate to the learner's prior knowledge. For example, short stories could include:

1. Weather – One afternoon you decide to go shopping. As you climb out of your car, you see that it is bright and sunny, without a cloud in the sky. You decide to leave your umbrella in the car so that you do not have to hassle with it while shopping. Two hours later, you remember that you have a dinner date with a friend. As you head back outside, the lovely weather has turned into a torrential downpour. If only you could have predicted the weather better…
2. University selection – As you approach your senior year in high school, you decide that college is the right path for you. However, when you start looking at universities, you realize that there are 1000s of them, each with their own set of considerations. Tuition, class size, programs of study, number of students, graduate salaries, average SAT scores, expenditures per student, reputation, private versus public, graduation rates, average student debt, location, faculty credentials, athletics, cultural experience, fraternities, sororities, and more. How can you make sense of all that data?
3. Buying a used car – After saving your money for the last two years, you finally have enough to buy a used car. But you are having problems. You know of a few dealerships around town, but is that the entire selection? You are sure that a list of dealerships must exist, but how can you find it? As you start looking at cars, you remember that there is a book that lists average car prices for various models, years, and conditions. How can you find those documents? How can you find the best value on a car?
4. Medical problem – On your first day of vacation in a foreign country, you wake up dizzy and nauseous. You are concerned that your symptoms may be more than just jet lag but do not want to have to pay for a hospital visit if you can avoid it. Unfortunately, it's the weekend and your doctor is not answering your calls. Is there some way you can check to see if these symptoms are just jet lag? Or should you be more concerned?
5. Group project dilemma – In one of your classes, the instructor has asked you to complete a project with 3 other students. But you live and work an hour away from school and cannot meet on campus when the other three students are available. With the deadline rapidly approaching, how are you going to complete the project?

Each of these stories highlights a different problem understandable to students (even if they have never personally experienced it) that requires an activity that's limited by our cognition. After presenting these stories, the lecture can address how information systems can overcome each of these limitations. At this point, definitions of the DSS categories can be presented, highlighting the similarities and differences between each category. The lecture could then transition into a discussion of related business problems and tools that facilitate solving these problems. To keep students cognitively involved, this part should not consist of a series of lists, but could include mini-cases, short stories, or demonstrations. The lecture should also provide examples that integrate with the various functional business units - finance, accounting, marketing, operations management, human resources, etc. Table 1 summarizes examples that might be used.

Table 1. Lecture examples

	Motivating examples	**Business problem examples**	**Tools**
Model-driven	Weather prediction	Economic modeling Marketing what-if analysis Production optimization	Excel Simulations Mathematical formulas Statistical formulas
Data-driven	Picking the ideal university	Discover trends in sales Discover trends in logistics	Data warehouse Data mining Business intelligence Excel
Document-driven	Buying a used car	Knowledge management Human resource documentation Capturing best practices	Knowledge management systems Intranets Search engines
Rule-driven	Diagnosing medical problems	Loan approval process Troubleshooting complex systems Mass training	Expert systems Neural networks Executive information systems
Communication-driven	Group project dilemma	Long distance meetings Collaboration on the same document Training small groups asynchronously	Web conferencing Email Social networks Wiki Learning management systems

Example 2. Active Learning Approach

As we stated above, one of the strengths of active learning is in motivating, in providing deeper integration, and in keeping students cognitively engaged. The dangers are that definitions may not be clearly specified or that conceptual confusions are not identified and eliminated. Perhaps one of the most direct ways for learners to be motivated while simultaneously witnessing an example is to participate in an activity using a DSS to solve a problem. With that in mind, the following five activities could provide a beginning to a class:

1. "What-if" analysis – Using a pre-populated spreadsheet with built in mortgage rate formulas, students could be challenged to discover what would be their total monthly payment for various specific inputs.

2. Pivot table – Using a pre-populated spreadsheet with fictional sales data for multiple products at multiple stores over several quarters, the students could be instructed to create a pivot table so as to better analyze the data.

3. Web Search - For document-driven DSS, the instructor could challenge students to find a trivial piece of information on the Internet without using a web search engine, such as how many children did Napoleon Bonaparte father.
4. Neural network - www.20q.net provides an interactive decision support game based on the classic game 20 questions.
5. Web conferencing – If the details are arranged ahead of time, the entire class module could be conducted through a web conferencing tool, such as Blackboard Collaborate, Centra, or Skype.

After completing these activities (summarized in Table 2), the instructor could provide a short lecture on each category, identifying typical business problems and tools used to solve these problems. It is important to clearly articulate the similarities and differences between the various categories of DSS. Lastly, the students could participate in another activity, where they are given several business problems (like those mentioned above in Table 1) and asked as a class to specify which category of DSS could best provide a solution for each problem. This last activity would help students integrate the concepts within their knowledge. Furthermore, misapplied categorization can help identify and eliminate conceptual confusions.

Table 2. Active learning activities

	Motivating Activities
Model-driven	Performing a "What if" analysis
Data-driven	Work with a pivot table
Document-driven	Searching the web
Rule-driven	Use neural net software
Communication-driven	Conduct class using a web conferencing

Example 3. Case Study Approach

Case study analysis provides a blend of traditional passive learning techniques and active learning techniques. The strengths of case studies are that they often cognitively motivate students by explicitly identifying real world business problems, by providing clear examples of a solution, and by integrating the concept with other business concepts. The danger is that the definitions of concepts may not be clearly articulated or that the example is too complex for students to appreciate or analyze. However, these dangers can be overcome with proper training in case study analysis and directed questions during discussion. If following a case study analysis, the instructor must carefully select five different cases studies that highlight the five different categories of DSS (for examples, see Table 3). These cases should be read and analyzed prior to class. The analysis should not only focus on the specifics of each case, but also cross case comparisons. During the class discussion, the instructor often takes on the role of a mediator, asking open-ended questions to facilitate student engagement and participation. To tease out the definitions, the instructor can ask students about the similarities and differences between the tools used to solve their respective case problems. With guided questions, the instructor can lead students to appreciate the different types of decision making activities each system facilitates, thereby opening the opportunity for students to intuitively and meaningfully grasp the DSS categories.

Table 3. Case study examples (from http://dssresources.com/cases/)

	Possible Case studies
Model-driven	PADAL helps US Navy aircraft land aboard carriers
Data-driven	The George Washington University Data-Driven Decision Support Project
Document-driven	University of Alberta increases timely access to policies and procedures
Rule-driven	Business rules drive modernization of legacy transaction systems at the California Department of Motor Vehicles
Communication-driven	The Space Shuttle Challenger Disaster: A failure in decision support system and human factors management

Conclusion

While active learning offers some hope for increasing conceptual understanding, its lack of appropriate focus leaves it suffering from mixed findings. Refocusing the discussion on ALT enables IIS instructors to develop courses that provide meaningful conceptual development. Consistent with epistemological, psychological, and pedagogical research, concepts cannot be learned in a vacuum, but are dependent upon an integration of concrete experiences and relationships with other concepts, within a proper motivational environment. In contrast, concepts learned in a rote manner quickly vanish from the learner's memory. Developing a hierarchically based conceptual understanding of content is the most appropriate way of promoting meaningful learning. By covering the simple concepts first, instructors can ensure a deeper understanding of ideas necessary for understanding complex ideas later in a course. We provided three examples of this approach for a DSS module in an introduction to information systems class.

References

Astin, A. (1993). *What matters in college?; Four critical years revisited*. San Francisco, CA: Josey-Bass.

Auster, E. R., & Wylie, K. K. (2006). Creating active learning in the classroom: A systematic approach. *Journal of Management Education, 30*(2), 333-353.

Ausubel, D. P. (1968). *Educational psychology: A cognitive view*. New York, NY: Holt, Rinehart and Winston.

Ballou, D. J., & Huguenard, B. R. (2008). The impact of students' perceived computer experience on behavior and performance in an introductory information systems course. *Journal of Information Systems Education, 19*(1), 87-97.

Bonwell, C. C., & Eison, J. A. (1991). *Active learning: Creating excitement in the classroom*. Washington, DC: Education Resource Information Center (ERIC).

Buckler, S. A., & Zien, K. A. (1996). The spirituality of innovation: Learning from stories. *The Journal of Product Innovation Management, 13*(5), 391-405.

Cowan, N. (2001). The magical number 4 in short-term memory: A reconsideration of mental storage capacity. *Behavioral and Brain Sciences, 24*, 87-114.

Dewey, J. (1959). *Dewey on education.* New York, NY: Bureau of Publications, Teachers College, Columbia University.

Di Vesta, F., & Smith, D. (1979). The pausing principle: Increasing the efficiency of memory for ongoing events. *Contemporary Educational Psychology, 4*.

Gallagher, J. & Reid, K. (2002). *The learning theory of Piaget and Inhelder*. Lincoln, NE: Authors Choice Press

Hake, R. (1998). Interactive-engagement vs. traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics, 66*(1), 64.

Harper, J. S., & Harder, J. T. (2009). Assurance of learning in the MIS program. *Decision Science Journal of Innovative Education, 7*(2), 489-504.

Hartley, J., & Davies, I. K. (1978). Note taking: A critical review. *Innovations in Education and Teaching International, 15*(3), 207–224.

Hassan, N. R., & Becker, J. D. (2007). Uncovering conceptual gaps in introductory IS textbooks. *Journal of Information Systems Education, 18*(2), 169-182.

Heriot, K. C., Cook, R., Jones, R. C., & Simpson, L. (2008). The use of student consulting projects as an active learning pedagogy: A case study in a production/operations management course. *Decision Sciences Journal of Innovative Education, 6*(2), 463-481.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41*(2), 75–86.

Locke, E. A. (2008). *Study methods & motivation: A practical guide to effective study* (2nd ed.). Irvine, CA: The Ayn Rand Bookstore.

Mayer, R. E. (2004). Should there be a three-strikes rule against pure discovery learning? *American Psychologist, 59*(1), 14-19.

Mykytyn, K., Pearson, A., Paul, S., & Mykytyn, P. P. (2008). The use of problem-based learning to enhance MIS education. *Decision Sciences Journal of Innovative Education, 6*(1), 89-113.

Novak, J. D. (2002). Meaningful learning: The essential factor for conceptual change in limited or inappropriate propositional hierarchies leading to empowerment of learners. *Science Education, 86*(4), 548-571.

Novak, J. D. (2010). *Learning, creating, and using knowledge* (2nd ed.). New York, NY: Routledge.

Novak, J. D., & Cañas, A. J. (2008). *The theory underlying concept maps and how to construct and use them*. Technical Report IHMC CmapTools 2006-01 Rev 01-2008: Florida Institute for Human and Machine Cognition.

Power, D. J., & Sharda, R. (2009). Decision support systems. In S. Y. Nof (Ed.), *Springer handbook of automation* (pp. 1539-1548). New York, NY: Springer.

Pridmore, J. L., Bradley, R. V., & Mehta, N. (2010). Methods of instruction and learning outcomes: A theoretical analysis of two approaches in an introductory information technology course. *Decision Science Journal of Innovative Education, 8*(2), 289-311.

Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education, 93*(3), 223-231.

Rand, A. (1990). *Introduction to objectivist epistemology* (2nd ed.). New York: Meridian.

Regehr, G., & Norman, G. (1996). Issues in cognitive psychology: Implications for professional education. *Academic Medicine, 71*(9), 988-1001.

Ruhl, K., Hughes, C., & Schloss, P. (1987). Using the pause procedure to enhance lecture recall. *Teacher Education and Special Education, 10*, 14-18.

VanDamme, L. (2006). The hierarchy of knowledge: The most neglected issue in education. *The Objectivist Standard, 1*(1).

Wankat, P. (2002). *The effective efficient professor: Teaching, scholarship and service*. Boston, MA: Allyn and Bacon.

Biography

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Automatic Grading of Spreadsheet and Database Skills

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Executive Summary

Growing enrollment in distance education has increased student-to-lecturer ratios and, therefore, increased the workload of the lecturer. This growing enrollment has resulted in mounting efforts to develop automatic grading systems in an effort to reduce this workload. While research in the design and development of automatic grading systems has a long history in computer education, only a few attempts have been made to automatically assess spreadsheet and database skills.

This paper has three purposes: (1) to describe the design of an assessment in the *Information Systems* course at the Open Polytechnic to assess students' spreadsheet and database skills, (2) to describe the development of an automatic grading system to assess spreadsheet and database skills, and (3) to compare automatic with manual marking to determine if automatic grading system is a feasible method of reducing workload.

The automatic grading system we developed uses Excel's user-defined functions to automatically check whether a feature or a function has been used. Since the outcomes from user-defined functions are scrambled, students verify their own answers by entering the results from these functions into an online quiz. As a result, there is no need for the lecturer to download, open, and check the actual software application. The system recognizes correct answers from these scrambled inputs and allocates marks. This system is integrated into the Moodle learning management platform and linked to the students' academic record database.

The main difference between the automated grading system for the assessment of spreadsheet and database skills described in this paper and existing systems is that the latter systems require the actual software application to be submitted for marking. The system described in this paper does not require markers to handle the application. Instead, it automatically checks the application while students are working on it, but grading is not performed until students answer specific quiz questions.

Practical experience with the automatic grading system has shown that the system significantly decreases turnaround time for the grading of assignments, while providing instant feedback to students on the correctness of their answers. At the same time, the system reduces the workload of the lecturer, freeing lecturers from administration and the time-consuming tasks of checking individual aspects of the spreadsheet and database applications. This allows them to allocate time to student support and other more crea-

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tive activities. In addition, the automatic grading system allows for a much finer probing of individual aspects of the spreadsheet and database applications, with no additional work required by student or lecturer.

The methods of marking were evaluated to address the main research question of whether there were significant differences between a human and an automated grading system. A comparison between the methods of marking (human and the automatic grader) based on data from 11 trimesters indicated no significant difference in the average marks and mark distributions in the case of the spreadsheet application. The comparison also showed that although the difference in the average marks in the case of the database application was significant, it did not mean that the effect of the method of marking was meaningful or important, as illustrated with the effect size. Nonetheless, monitoring of the automatic grader results is recommended.

Keywords: automatic grading, e-assessment, database skills, distance education, software skills, spreadsheet skills.

Introduction

Growing student numbers in the 40-plus age range and increased student-to-lecturer ratios have led many academics to consider alternative forms of assessment in tertiary education, such as automatic assessment systems and, within these systems, automatic grading systems. A shift in the role of the lecturer has also triggered work on the further development of these systems. Malmi, Korhonen, and Saikkonen (2002) point out that advances in automatic assessment systems are the result of the changing roles of lecturers in the new learning paradigm; lecturers become facilitators, creating the learning environment, providing guidelines, commenting on students' work, giving feedback, and so on. Advancements in technology have also enabled the development of automatic assessment, as well as generally improving the student learning experience through, for example, learning management systems such as Moodle and Blackboard.

The broadest definition of e-assessment is given in Malmi et al. (2002) and adopted in this paper. Malmi et al. (2002) defines e-assessment as "the end-to-end electronic assessment processes where ICT (information and communication technology) is used for presentation of assessment activity, and the recording of responses," which "includes the end-to-end assessment process from the perspective of learners, tutors, learning establishments, awarding bodies and regulators, and the general public" (p. 6). They also make a distinction between computer-based assessment and computer-assisted assessment. The former refers to assessments delivered and marked by computers, while the latter relies on computers only in part.

There are differences between assessment and grading. In this article, however, the terms 'computer-based assessment', 'automated grading systems', and 'automatic marking systems' have been used interchangeably, as they have been in most of the studies listed in the references. The main reason for doing this is that our automatic grading system does not simply evaluate the learning and performance of students (the core elements of the definition of grading); it also provides detailed feedback for every question and suggests possible reasons for any incorrect solutions and answers. Our automatic grading system, therefore, also helps to improve student learning, which is the goal of assessment. In the following literature review, we kept the original terms authors used in their studies to describe their systems.

Computer education research has focused on automatic grading systems for almost 50 years (see Whitelock & Brasher (2007) for an overview of three generations of automatic assessment systems). However, there have only been a few attempts to build a grading system for the automatic assessment or the grading of Office skills, that is, word-processing, spreadsheet, and database skills (Hill, 2003, 2004; Koike, Akama, Chiba, Ishikawa, & Miura, 2005; Koike, Akama, Morita, & Mura, 2006; Zhenming, Liang, & Guohua, 2003). The major expectation in this research was that the introduction of automatic grading systems would significantly decrease turnaround time for assessments and, at the same time, reduce the workload of the lecturer by removing the need to check the software application students developed. However, building an automatic marking system is not a quick nor a cheap option, as Koike et al. (2006) emphasized.

Research Goals, Questions, and Hypothesis

The goals of our research were to build an automatic grading system to assess advanced spreadsheet and database skills and to compare automatic with manual marking. More specifically, our first goal was to convert the practical parts of the *Information Systems* course assignments (building spreadsheet and database applications) into two computer-marked assignments quizzes in Moodle.

The aims of this conversion were twofold:

1. to design and develop tasks for the assessment of spreadsheet and database skills by distance, without opening and checking the software applications,
2. to automate the marking of practical software applications.

The conversion of assignments into the Moodle quiz format was undertaken with the expectation that it would be beneficial for both students and lecturers. Students would get instant feedback, and their work would be marked objectively. The workload of lecturers would be reduced, allowing them to allocate more time to teaching, the updating of course material, and student support.

Our second goal was an evaluation of whether our automatic grading system allocated marks as a human marker would. Given our research interest, the main research question asked in this paper is: do significant differences exist between marks allocated by humans and those allocated by an automatic grading system? It is hypothesized that there is no significant difference.

Before addressing these questions, a brief overview of related work on platforms for the automatic assessment (i.e., grading or marking) of Office skills is presented. In the section 'E-assessment: Design Issues and Challenges,' we discuss our approach to the design of a grading system for assessing spreadsheet and database skills. In the section 'E-assessment: Implementation Issues,' we give an overview of our automatic grader system and its components, briefly describing the issues we had with its implementation. The next section gives an evaluation of the methods of marking. The last section outlines our conclusions and future work.

Literature Review

Drivers for the use of Computer-based Assessments

According to Tshibalo (2007), academic workload is increased in higher education and online assessments may help reduce this workload by helping lecturers manage the large volume of marking and assessment-related administration. Swithenby (2006) also listed several drivers for the increasing use of e-assessments. He included both economic (that is, demand for portable qualifications and a cost-effective means of testing) and pedagogical drivers, and the most important pedagogical driver is that of rapid feedback in the form of both marks and comments, since they have the potential for the immediate shaping of learning.

Whitelock and Brasher (2006) also cited several drivers for the adoption of e-assessment, including perceived increases in student retention and the enhanced quality of the feedback the student receives. They also cited the flexibility of e-assessment for distance learning, the strategies it provides to lectures for coping with large student numbers, the inherent objectivity in marking, and how it makes more effective use of a learning management system.

There are, however, some potential weaknesses and barriers to further increases in the use of computer-based assessments. As Swithenby (2006) pointed out, there is still some "cultural antipathy to computer-based assessment." According to this view, the use of computer-based assessments is impersonal, suitable only for the assessment of tasks at a low cognitive level or those that require closed responses.

Some academics feel that computer-based assessment cannot test high order skills, such as synthesis and analysis (Musham, 2004). We feel that the acceptance and effectiveness of multiple-choice tests depends heavily on their design. With properly designed computer-based assessments, even the higher ranked objectives of Bloom's taxonomy (such as application and analysis) can be reached. As the development of computer-based assessment requires academic staff time and a high initial investment, Whitelock and Brasher (2006) see the need for academic staff development time as one of the major barriers for the wider use of computer-based assessment. Similarly, Buzzetto-More and Alade (2006) concluded that "assessment programs are time consuming efforts that require planning and foresight. Effectiveness is dependent on institutional and administrative support as well as a long range plan for sustainability that includes technological preparedness" (p. 266).

Use of Automated Grading Systems for Office Skills

As previously stated, there have been only a few attempts to develop automated grading systems for assessing Office skills. Waldman and Ulema (2008) briefly described three different methods for implementing a custom grading program for Excel. The first option (which we have partially adopted in the design of our automated grading system) requires writing a grading program in Excel using Microsoft's Visual Basic for Applications (VBA). The second option requires writing a program that interfaces with a running copy of Excel (Hill's MEAGER, described later, is an example of such a program). The third method (adopted by Waldman & Ulema, 2008) "is to write a program that simply reads the student's Excel data and extracts the data for the items that need to be graded" (p. 77).

The third method requires an Excel file to be submitted for marking. As the number of submissions increases both in print and online (as an attachment to an email or uploaded to the learning platform), these submissions slow down the marking process (see Kline & Janicki, 2003). Each student receives a file that contains an embedded identifier which addresses the issue of plagiarism. Once the students return the Excel file, the marker runs the automated grader that compares the work of the students with the grading templates. These grading templates are text files that list the elements of the Excel file to be graded, the acceptable correct answers, mark allocation, and feedback comments for incorrect answers.

The current version of the system developed by Waldman and Ulema (2008) permits only two correct answers to be built in to each spreadsheet cell. This feature decreases the benefits of automated grading when more than two variations are expected in some questions. In such cases, human markers are required. Waldman and Ulema have included the following items in the automatic grading system for spreadsheet applications: name and existence of the worksheet; the value of a particular cell, formula, and range name (cells associated with a range name); the use of range names; and checking the validity of formulas and graphs (existence, type, legend, axis label and data range).

Koike et al. (2005) built an automatic marking system for intermediate Office skills. They wrote programs in VB.NET, and these programs automatically mark MS Word and Excel files. For example, the program for MS Word checks page settings, paragraphs, indents, figures, tables, fonts, colors, texts, and so on. A student may download the program and run it on their files for formative assessments.

One of the most frequently cited automated grading systems is developed by Hill (2003, 2004). Hill developed two automatic grading systems for Microsoft Office applications, namely Excel (Microsoft Excel Automated Grader - MEAGER) and Access (Microsoft Access DataBase Automated Grading System - MADBAGS). These systems were constructed to be used by lecturers.

MEAGER is a generic grading program that compares the Excel workbook submitted by the student against the lecturer-supplied solution workbook and allocates marks for each submitted file. MEAGER also includes reports and tools for the detection of plagiarism. Once students submit their Excel workbooks, MEAGER compares their files with the correct solution, that is, a grading template (an Excel file prepared by the lecturer).

MEAGER is a Microsoft Access application. It extracts attributes from both the student's and lecturer's workbook and stores them in separate tables for each attribute. MEAGER then compares each attribute in the student's and lecturer's tables, identifies differences, and records them in an errors table. The lecturer can use this errors table to identify which particular spreadsheet skills the student is lacking. MEAGER marks and embeds a grade report in the student's workbook. The updated student workbook can then be sent back to the student.

MEAGER grades various worksheet attributes: text labels, numbers, formulas, fonts, cell alignments, number formats, merged ranges, worksheet names, chart types, location and source data, and so on. It does not grade conditional formatting, embedded objects or drawing objects, and controls. MEAGER marks in greater detail than human graders and can detect errors a human grader cannot while reducing the time required to grade assignments. However, there are some weaknesses in MEAGER. For instance, the lecturer still has to download and upload the student workbook when using MEAGER. Also, the automated grader is, in some cases, too rigid to accept an alternative but correct answer if it does not match the specimen answer exactly.

Marking formulas in Excel can be a challenging task (see Hill, 2004). This is because, in some cases, the same result can be achieved in different ways by using different formulas/functions. MEAGER approached this challenge by applying an interpreter for the symbolic manipulation of mathematical expressions (like Maple or Mathematica). An assignment should be written very strictly, with no room for interpretation or the use of an equivalent formula. Otherwise MEAGER would be unable to differentiate between two equivalent formulas, even though they answer the same question correctly. In this case, a lecturer's intervention is required.

We have adopted a different approach to this problem by explaining the tasks and requirements to students clearly and in detail and by specifying in the assignments the particular Excel/Access function or specific formula to be used. So when a function or formula is entered in the online quiz, students know from the assignments which particular function or formula they should use. It might be considered that this tactic is too restrictive, that it reduces the freedom of students to use their own modeling knowledge to solve particular tasks. At the same time, however, this approach ensures that all the software functionalities and features covered in this introductory course are really fully grasped by students and assessed by lecturers. A more advanced course would probably require a different automated grading system, one that would have more flexibility in handling students' solutions and where the focus is more on the optimal solution and modeling approach rather than on a set of required Office skills. Our automatic grading system, however, also accepts an equivalent formula or an alternative solution. This is hard-coded in the quiz. In other words, our system would recognize an alternative solution and mark it as correct.

MADBAGS is an Access Grader that works similarly to MEAGER. It embeds an "Errors" table in the student's database. MADBAGS compares a correct version of an Access database with a student version and records the errors in an Access table. It grades the following database attributes: table data, table structure, field attributes, indexes, primary keys, relations, SELECT queries, total queries, DELETE and UPDATE queries. MADBAGS does not grade data access pages, macros or modules, and can detect whether a form or report is absent although it does not grade the form or report in detail.

E-assessment: Design Issues and Challenges

The main motivation for the creation of a new system for automatic grading was that all the existing systems reviewed still require the actual software application (that is, Excel workbook and Access database) to be submitted for marking. The automated grading system is then executed in order to compare the student's solution with the "correct" solution and to provide relevant feedback. We wanted to avoid the actual handling of software applications, because marking large cohorts with existing automated grading systems would still be a time-consuming process; it requires downloading a submitted application from the learning management platform, passing it through the automated grading system, and then either returning the report back to student or returning the actual application. Our system was designed with the idea of eliminating all these steps by automated marking while the application is still with students.

The Open Polytechnic uses Moodle integrated with the student database. This enables electronic submissions for essay-like assignments (both as an attachment and as questions in quizzes), online marking and, in the case of Moodle quizzes, storing marks directly (without human intervention) in the student record. This was an additional motivation for us to design and develop online assignments that could be automatically marked.

Course and Assignments Descriptions

The *Information Systems* course is an introductory Level 5 course for the Information Systems and Technology major at the Open Polytechnic of New Zealand. The purpose of Level 5 on the ten-level New Zealand Qualification Framework is to qualify individuals with theoretical and/or technical knowledge and skills within a specific field of work or study. The course has an average of 100 students per trimester with a multicultural student body of approximately two-thirds women and one-third men. Most students are between the ages of 30 and 50, and the majority of students are employees or self-employed. Students study the course in Moodle through distance learning. Students need to successfully complete a pre-entry test before enrolling on this course. This test ensures they have basic skills in Excel and Access. However, there is still a significant variation in their spreadsheet and database skills.

As part of student assessment, students are required to build spreadsheet and database applications. They also need to create a presentation and write reports to a client in a case study that describes a small, local New Zealand business. The Excel and Access applications are developed around this case study. In this course, only spreadsheet and database skills are graded.

The *Information Systems* course has two assignments:

Project 1:	Task 1: Build the "Tiki" sales tracking system
	Task 2: Business information system research
Project 2:	Task 1: Build the "Tiki" database system
	Task 2: PowerPoint presentation
	Task 3: SDLC and telecommunications technologies

Previously, students were asked to submit the actual software applications, the actual PowerPoint presentation, and written reports using Word templates. We designed these practical tasks to cover the "application" and "analysis" objectives of Bloom's taxonomy. Students were also asked to use their applications to answer a few questions related to different scenarios that were relevant to the business from the case study.

The Design of Assignment Tasks

All the automatic grading systems for spreadsheet and database skills that we reviewed (Hill, 2003, 2004; Kline & Janicki, 2003; Koike et al. 2005; Russell & Cumming, 2005; Waldman & Ulema, 2008) require students to submit the actual application. We designed an assignment that ensured particular features of the Office software were used, but without asking students to submit the actual application. This was the most challenging part of the conversion process. Since the dataset in the case study assigned to students was small in size, students might try to find solutions manually. Therefore, the assignment tasks had to be designed in such a way as to prevent students from finding solutions manually.

We will use the spreadsheet application and pivot table the students were asked to create to illustrate our approach. After they created a pivot table from the raw data, we asked them to change the field settings in the pivot table to summarize the field by standard deviation. While most of them would be able to manually create a two-way pivot table, even those who completed a statistical analysis course would not be easily able to manually calculate a standard deviation and change the display of data in the pivot table.

There is always a possibility for students to short-circuit an assignment task by calculating the final result manually. In such cases, a human may need to review the quiz. So we asked the students to include a few screenshots of the most important steps into their essay questions, to ensure that the tasks were completed as required. However, these essay questions were marked by a human and not by an automated essay grading system.

E-assessment: Implementation Issues

We partially adopted the first implementation option described in Waldman and Ulema (2008) – writing a grading program in Excel using Microsoft's Visual Basic for Applications (VBA). We used user-defined functions and Excel objects to check if the attributes in a student workbook were according to the requirements and if a particular function/feature was used.

Students collected information from their workbook on discrepancies between the requirements of the task and their solution. The outcome was stored in a separate **Answers** worksheet. The results of the checking procedure were "scrambled" using the Excel random function. This function generated a random number from one of the subset of numbers ("correct" and "incorrect" set of numbers), depending on whether the answer was correct or not, or if the attribute was according to our requirements.

Students were asked to enter these numbers from the **Answers** worksheet into the online quiz. The online quiz recognizes whether the number belonged to the "correct' or "incorrect' set of numbers and allocated marks accordingly. Similarly, Russell and Cumming (2005) built in the so-called "hidden database check" to ensure students did not complete the SQL query manually. They also penalized students for the inefficient use of SQL statements (that is, the statement could be correct, but had a query twice as long as the sample solution query) or to give a quality measure to the SQL statement.

Specific spreadsheet skills, such as conditional formatting and goal seek, were assessed in different parts of the workbook. Utilizing the same group of cells to assess multiple skills in using Excel complicates automatic grading because a subsequent activity overwrites the result of a former activity – as explained in Waldman and Ulema (2008). Therefore, each of such skills should be assessed in a separate worksheet.

Description of the Automatic Grader

Our grading system has two parts: a Moodle quiz based mostly on Cloze-type questions where students get immediate feedback on their submission, and a set of essay-type questions marked by a human marker.

Similarly Amelung, Piotrowski, and Rösner (2006) developed a three-step approach: (1) an electronic multiple-choice test, (2) electronic submission for essay-like assignments and (3) automatic checking and marking of programming assignments with immediate feedback. Implementation of their system was carried out in Plone, another open-source content management system.

For our practical quizzes in both the *Information Systems* course assignments, these are marked automatically without intervention from lecturers. As earlier mentioned, students do not submit the applications. Instead, using the application, they answer questions and insert the requested information into the quiz. The rest of both assignments are essay questions (marked by a human marker).

Preparing a spreadsheet for use

For Project 1 Task 1 (a spreadsheet task), students download some Word documents with data for this task. They also download an Excel file, which contains four worksheets. The students then edit the Excel file as required by the assignment. The Excel template helps us in the clarification of the assignment and in controlling the format of worksheets. This simplifies the marking process and focuses the students' attention on the Excel features rather than on formatting issues.

Detailed instructions are provided on how to prepare the initial workbook. These activities ensure that all the user-defined functions that are required for checking the student workbook attributes are functioning. We ask the students to complete an example quiz to ensure that they will not have technical problems with the quiz. The example quiz forms part of an incremental assessment strategy. Russell and Cumming (2005) also used an incremental assessment strategy by splitting their assessment into four assignments. When the student had completed 75% of a tutorial group, the related assignment was made available.

The example quiz has an **Answers** sheet similar to the **Answers** sheet in our Project 1 quiz. This forces students to prepare the spreadsheet for use before attempting the quiz for Project 1. When they score 100%, the password for Project 1 Quiz is delivered to them. The example quiz does not contribute towards the student's grade, thus students have the opportunity to take the example quiz until they are comfortable navigating the Moodle quiz. Lecturers addressed any technical problems and observed the students' reactions to the quiz.

The **Answers** sheet is password-protected. It contains answers to the following questions:

- How many worksheets does the Excel workbook contain?
- Are the worksheets named and ordered as required?
- Are the column labels replaced with descriptive names?
- Is the currency format used where appropriate?
- Is the requested information inserted in the left/right footers?
- Is the page setup as required?
- Has the AutoFilter been used?

These are requirements built into the assignment. Although students know about these requirements, the numbers the system inserts into this **Answers** worksheet have no meaning to them. They will later enter these numbers in the Moodle quiz.

User-defined functions

The user-defined functions check to verify that the attributes in a student workbook meet the requirements and if a particular function/feature has been used. The outcomes of these user-defined functions are then used in the **Answers** worksheet to generate random numbers. There are two possible ranges of random numbers: numbers from the first range indicate the correct answer, while numbers from the second range indicate an incorrect answer. Students are asked to enter these numbers in the Moodle quiz.

For each of the questions listed in the previous section, an Excel function (a user-defined function) was created. For example, the function `TestLeftFooter()` in Figure 1 checks if the **Summary** worksheet has the name of the worksheet in the left footer.

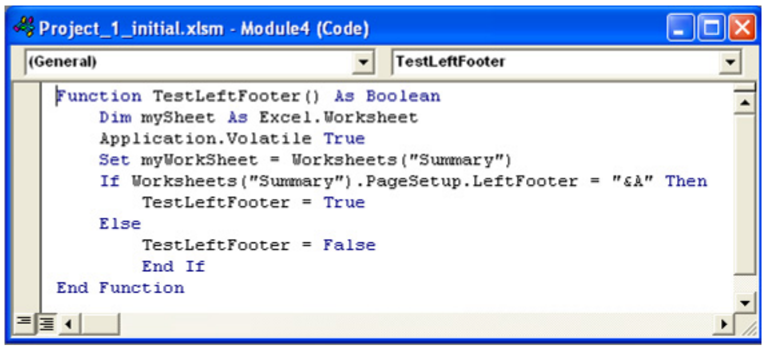

Figure 1: User-defined function – `TestLeftFooter()`

For further protection, we scrambled the answers from these functions by using the `RANDBETWEEN()` Excel function. This function assigns a random number from a specified interval to the correct answer. Students are asked to enter this number in the online quiz. Any number from the specified interval will be accepted as a correct answer. These numbers change each time a student opens or modifies the Excel workbook.

How the quiz works

For Excel functions such as IF and VLOOKUP, each argument was entered separately. This allowed us to allocate marks for a single argument if it was correct and reduced the chances of students incorrectly entering a formula or function. At the same time, it ensured students did not miss some of the arguments.

The following tasks in the Project 1 quiz (Step 6; see Figure 2) illustrate which answers from the **Answers** worksheet students need to insert. These four answers are located here because in the Step 6 task we ask them to “make the **Summary** worksheet fit on a single page and be centered horizontally and vertically when printed in landscape orientation.”

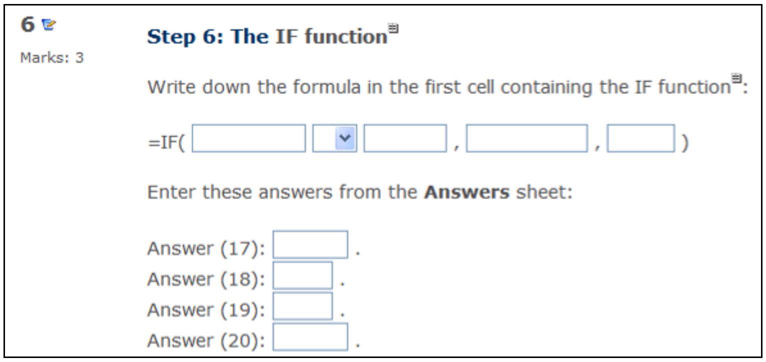

Figure 2: Quiz question

The system will mark the quiz automatically on submission (as shown in Figure 3). The actual answers have been removed from this screenshot.

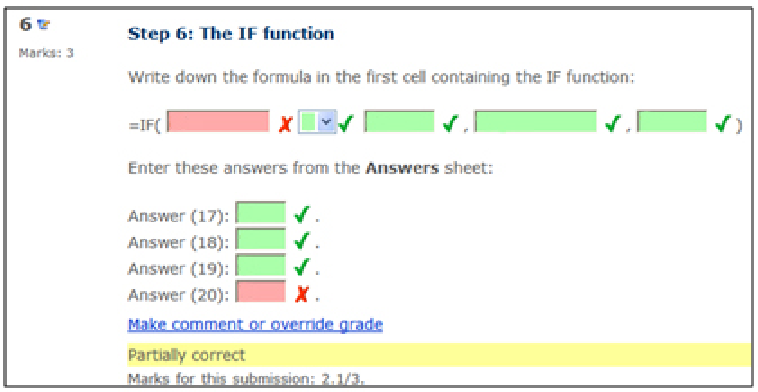

Figure 3: Quiz answers

If the student scrolls the mouse over their answer, an indication of whether their answer is correct or not will pop up on the screen. However, students will not be able to see the correct answer. Most of the questions are in the form of a Cloze-type question. The Cloze-type question combines multi-choice, numerical, and short answer types of questions into a single question. It allows the allocation of a fraction of mark for partially correct answers. For example, `=Correct Answer` is a correct answer, but if the student enters `=Partially` correct only, they will be awarded 25% of the full mark for this particular question (as shown in Figure 4). The Cloze question also accommodates the multiple ways in which each question can be answered and scored correctly. For instance, if the student is asked to enter the date they can enter 12-May-09, 12/05/09 or other date formats.

Each question in the Cloze type of question can have a different weight, dependant on how important the question is compared to others. For example, the first question (SHORTANSWER) has a weight of 2, while the next question (MULTICHOICE) has a weight of 1. This means the first question will produce twice as many marks as the second one if both are answered correctly.

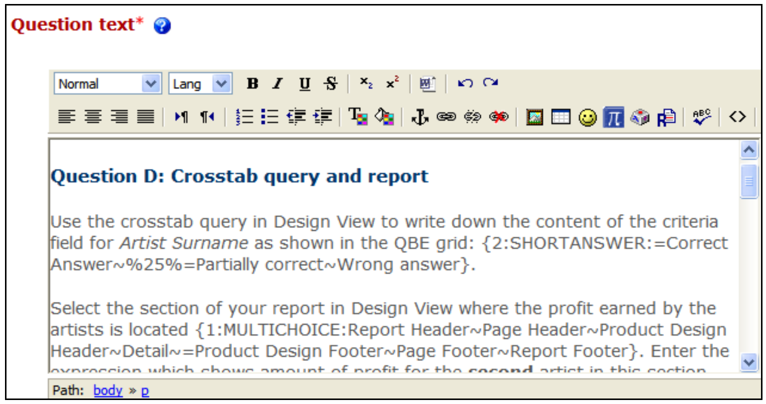

Figure 4: The structure of the Cloze type of question

After the final assignment submission date, scores can be automatically transferred to the student management system overnight, if the link from Moodle has been established.

Evaluating Methods of Marking

Methodology

An evaluation of the methods of marking was done as a quantitative study. Our research hypothesis was that there is no significant difference between the marks of a human and an automated grading system. A finding of no significant difference would strongly support our claim that the automated grading system developed in this paper worked as well as a human marker.

An appropriate approach to evaluating the methods of marking would be if a human and an automated grading system marked the same papers. We could then determine the inter-rater reliability using statistics such as Cohen's kappa, inter-rater correlation, concordance correlation coefficient and intra-class correlation. This was not possible for the reasons that follow. Firstly, before the introduction of the automatic grader, students submitted the actual spreadsheet and database applications, which were then marked manually. Copies of these applications were not stored, that is, they are not available now to be marked by the automatic grader. Even if we had them, they are not prepared in the way requested in the "Preparing spreadsheet for use" section. Secondly, after the introduction of the automatic grader, students do not submit the actual spreadsheet and database applications. So the actual applications are not available for manual marking.

As a result of these two reasons, an evaluation was undertaken by comparing the distributions of marks allocated by the automatic grader and those allocated by a human marker. It was assumed that the student population before and after the introduction of the automatic grader was the same, and that the students on this course were no more and no less smart than past students before the introduction of the automatic grader. If this was the case, a shift in the distribution and the mean value to the right or to the left would be evident. With these assumptions, the comparisons of the mark distributions and mean values are justified and provide enough information to decide if there are significant differences between human and automated grading system marks, at least for the overall marks.

We compared different aspects of distributions of marks allocated by human and automated grading system using histograms, box-plots, and descriptive statistics. The hypothesis that there was no difference between average marks allocated by a human and an automated grading system was tested using the two sample *t*-test and Wilcoxon rank-sum test.

Results

The online quizzes were first implemented in Trimester 2, 2009. From the regular course evaluation administrated by the Open Polytechnic Academic Office at the end of each trimester, we can conclude that students felt they got immediate feedback and deserved the marks they scored. A few students disliked that the automatic grading system required extreme attention to such details as spelling and spacing in their input. One could easily argue, however, that this is a requirement in the real world – results that are 'almost' correct would not be accepted elsewhere. It is critical for students to persevere with the assignment until it is accurate and complete.

For this evaluation we gathered data, that is, assignment marks from 11 trimesters. In the first five trimesters, a human marked both projects. The software applications were marked automatically in the following six trimesters. The distributions of marks for both software application parts of the projects are presented in Figure 5 (the left pane shows the spreadsheet and the right pane shows the database application). The label on the horizontal axis indicates trimester and the year (that is, 'T1,11' should be read as Trimester 1, 2011). The first six box-plots on the left on these two diagrams show the distribution of marks allocated by the automated grader (the online quizzes in Moodle). The remaining box-plots show the distribution of marks allocated by human markers in each trimester.

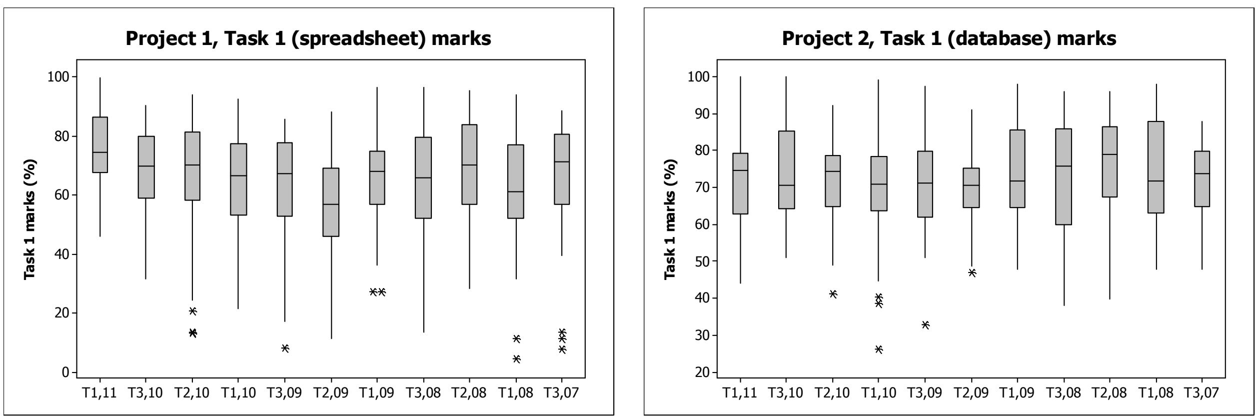

Figure 5: The distribution of marks by trimesters

There are obvious variations in mark distributions between trimesters. The outliers were detected in a few distributions; we show these as asterisks. But only two distributions, both in Trimester 2, 2009, are a bit different from the others. In the case of the spreadsheet application, the whole mark distribution is shifted toward lower marks (also indicated with the lowest median – the central line within the box), while in the case of the database application the size of the box (that is, the interquartile range) is the smallest of all the boxes in this pane indicating the smallest variations in the marks. However, after a small adjustment of the automatic grader in the following trimester, the mark distributions became similar to the distributions we had before introducing the automatic grader. Overall, after an initial adjustment of the automated grading system, we can say that Figure 5 shows no significant differences in the distributions of marks by trimesters. In other words, the introduction and use of the automated grading system had little impact on how the marks were distributed.

To check if there are differences in the mark distributions and the average marks between the marks allocated by the method of marking, we have combined all marks from these trimesters for each software application separately. The first two panes at the top in Figure 6 show histograms of marks, while the two panes below these show box-plots for each method of marking and each application. Two histograms for Project 1, Task 1 marks are fairly similar, both being slightly skewed to the left. The histograms for Project 2, Task 1 marks indicate that the automatic grader gives a symmetric distribution, with the majority of marks concentrated in a rather narrow interval, while manual marking gives a distribution slightly skewed to the left, with greater variations.

These features of the distributions are even more prominent on the box-plots. The mean mark for Task 1 in both projects for each method of marking is indicated and connected. In each case, the distribution of the observations that are not outliers is fairly symmetric. However, the outlying values for both automatic and manual marking suggest non-normal populations. This should not be a major problem when applying the two sample *t*-test because of the large sample sizes.

Overall, the distribution of marks for the automated and manual methods of marking are shaped similarly and the average marks are quite close to each other, particularly in the case of Project 1, Task 1 (spreadsheet application) marks. A small difference between the distributions and average marks in the case of Project 2, Task 1 (database application) requires further investigation. However, both histograms and box-plots provide strong evidence in support of no major differences between human and automated grading.

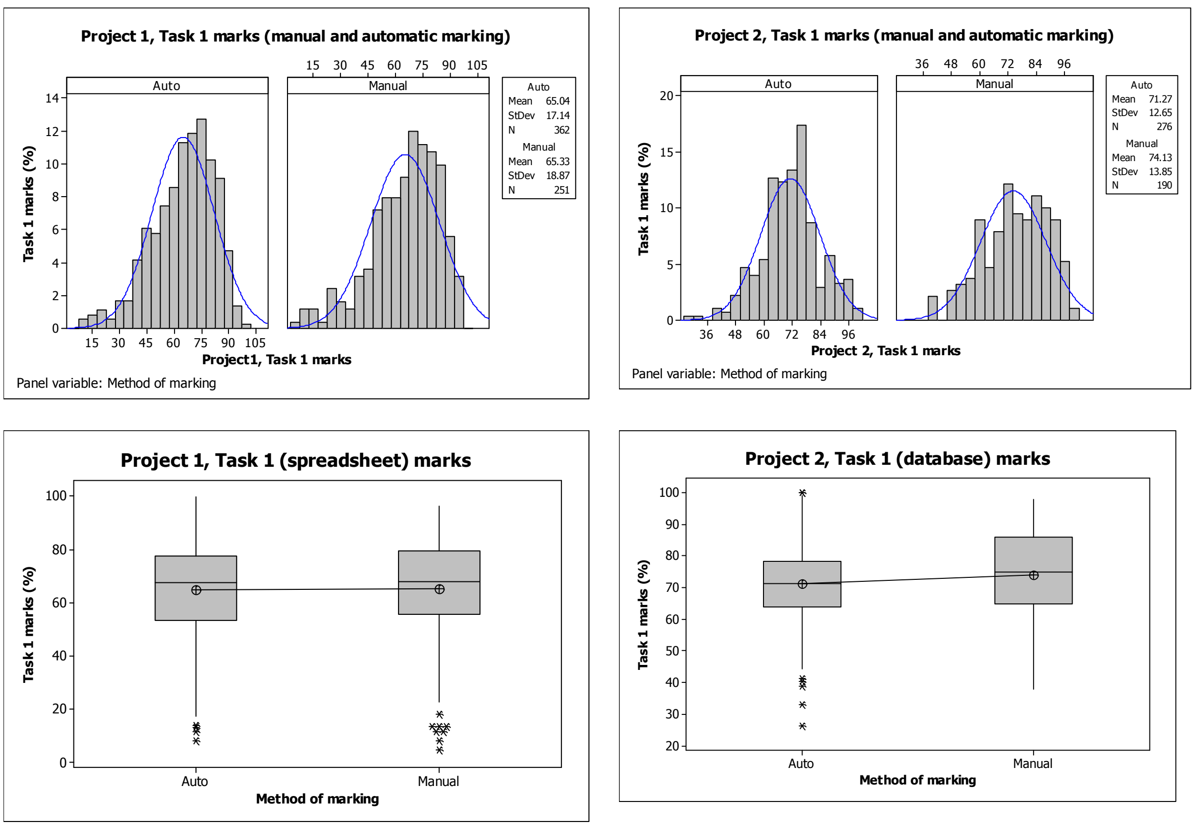

Figure 6: The distribution of marks by method of marking

The main summary statistics are presented in Table 1. Both measures of centre, that is mean and median marks for Project 1, Task 1 marks, are quite similar. The measures of variation, that is, standard deviation, coefficient of variation, and interquartile range, are also quite similar. Comparing the statistics in the last two columns in Table 1 confirms what we have concluded about the distribution of the Project 2, Task 1 marks – that the mean, median, and interquartile range for the automatic grader marks are slightly smaller than the manual marks.

Table 1: Selected descriptive statistics

Statistic	Project 1, Task 1 mark		Project 2, Task 1 mark	
	Automatic	**Manual**	**Automatic**	**Manual**
Number of marks	362	251	276	190
Mean	65.04	65.33	71.27	74.13
Standard deviation	17.14	18.87	12.65	13.85
Coefficient of variation	26.36	28.89	17.75	18.69
Minimum	8.18	4.55	26.32	38.00
First quartile	53.48	55.68	63.94	65.00
Median	67.61	68.18	71.18	75.00
Third quartile	77.83	79.55	78.24	86.00
Maximum	100.00	96.59	100.00	98.00
Range	91.82	92.04	73.68	60.00
Interquartile range	24.35	23.86	14.29	21.00
Skewness	-0.11	-0.87	-0.18	0.42
Kurtosis	0.29	0.59	-0.40	-0.52

To test the hypothesis that there are no differences between automatic grader and manual marks we conducted a test of significance. We tested a hypothesis that there are no statistically significant differences between the mean marks obtained by manual marking and those of automatic marking. The result of the two sample *t*-test is presented in Table 2.

Table 2: Test of significance

	Project 1, Task 1 mark	Project 2, Task 1 mark
Two sample *t*-test		
Null hypothesis	The means of the marks are equal	
Alternative hypothesis	The means of the marks are not equal	
t statistic	-0.20	-2.27
Degrees of freedom	503	381
P-value	0.844	0.024
Effect size (*r*)	0.0089	0.1155
Wilcoxon rank-sum test		
Null hypothesis	The medians of the marks are equal	
Alternative hypothesis	The medians of the marks are not equal	
W statistic	109842.5	60737.0
P-value (adjusted for ties)	0.5493	0.0094

Applying the two sample *t*-test to Project 1, Task 1 marks we got t=-0.20, df=503, P-value=0.844. Because the *P*-value of 0.844 is greater than the standard 5% level of significance, we can say that there is not enough evidence to reject the null hypothesis. In other words, we can attribute the difference in the Project 1, Task 1 means to sampling variance.

When testing the same hypothesis for Project 2, Task 1 marks we got t=-2.27, df=381, P-value=0.024. Because the *P*-value of 0.024 is less than the standard 5% level of significance, we can reject the null hypothesis at that level of significance. In other words, we cannot attribute the difference in the Project 2, Task 1 means to sampling variance but to the method of marking.

A word of caution is needed when interpreting this result. While the test statistic is significant, it does not mean that the effect it measures (the method of marking) is meaningful or important. In other words, because of the large sample size, even a very small or unimportant effect can turn out to be statistically significant. This is what happened with Project 2, Task 1 marks. To quantify the effect size we used the correlation coefficient as an objective measure of the importance of an effect. In the case of Project 2, Task 1 marks, the effect size is 0.1155 and that is, according to Cohen (1992), a small effect. That is, the method of marking explains only 1% of the total variance in Project 2, Task 1 marks. The effect size is even more negligible – as in the case of the Project 1, Task 1 marks. Since we kept the outliers that caused the departure of the marks distributions from normality in the dataset, we also used a non-parametric equivalent of the two sample t-test, that is, the Wilcoxon rank-sum test, to compare the median marks of these two populations. This test does not depend upon an assumption of normality.

The values of the Wilcoxon rank-sum statistic and *P*-values are presented in the lower part of Table 2. These tell us that we reached the same conclusion at a 5% level of significance, using both the parametric *t*-test and nonparametric equivalent, as the Wilcoxon rank-sum test: there is no statistically significant difference between the Project 1, Task 1 medians when using different methods of marking (automatic vs. manual). However, in the case of the Project 2, Task 1 median marks, the Wilcoxon rank-sum test suggests we reject the null hypothesis of no difference between median marks. The discussion of the effect size above suggests that we should not be too concerned with the test result in the case of the Project 2, Task 1 marks. However, we may consider a fine adjustment of the Project 2, Task 1 test so that the marks distribution more closely matches the distribution of marks obtained when a human marked students' assignments.

In summarising these results, we can say that in spite of a small variation in marks between a human marker and an automated grading system, experience in the past eleven trimesters confirms our main research hypothesis – that there are no significant difference between the marks allocated by a human marker and the marks of a spreadsheet automated grading system. In the case of a database automated grading system the difference is significant, but the effect size is very small.

Conclusion and Future Work

This paper describes the design of an assessment and the development of an automatic grading system to assess advanced students' spreadsheet and database skills in the *Information Systems* course at the Open Polytechnic.

The automated grading system discussed in this paper differs from other automated grading systems developed for Office skills (Hill, 2003, 2004; Kline & Janicki, 2003; Koike et al. 2005; Russell & Cumming, 2005; Waldman & Ulema, 2008) in one major aspect. That is, students are not required to send the developed software application and lecturers are not required to receive and check the actual application. This is the major advantage of this automated grading system over other systems because, as Kline and Janicki (2003) emphasized, the physical handling of submitted assignments can become difficult and time consuming.

Using the user-defined functions in Excel, we have been able to check the attributes of software applications and if the requested feature or function was used appropriately. Lecturers were not required to open the actual application because students verified their own application by entering scrambled user-defined functions outputs in the online quiz. Alternative correct answers and partially correct answers were coded in the online quizzes. This allowed for flexibility in the acceptance of different solutions.

In a similar way to one of the methods proposed by Waldman and Ulema (2008) for the implementing of a custom grading program, our automated grading system is based on the use of Microsoft's Visual Basic for Applications (the same approach adopted by Koike et al., 2005). Other grading systems – such as Hill's MEAGER system – require a program that interfaces with a running copy of Excel. A major disadvantage of our automated grading system is that the answers are hard-coded into the system. While this is also a limitation of the other grading systems (such as the system developed by Kline & Janicki, 2003, which allows only two correct answers), we have built in a few alternative acceptable answers to cater for possible variations in the solutions provided by students.

Marking formulas in Excel can be quite difficult because the same result can be achieved using different Excel functions and formulas. Hill (2004) addressed this problem by using an interpreter for the symbolic manipulation of mathematical expressions. We adopted a different approach – that of limiting the students' options so that they did not use a function other than the one expected. This can be interpreted as restricting the freedom of students to solve particular tasks using their own modeling knowledge, but it can be argued that this approach ensures that students fully grasp the core software functions and spreadsheet and database skills required in the course.

An evaluation of the methods of marking (manual vs. automatic grader) confirms that the automatic grader allocates marks in a similar way to a human marker. In the case of the spreadsheet application, the marks distribution for the automatic grader matches the distribution of the human marker. The test of significance confirms that the both mean and median marks for these two methods of marking are not statistically different. While the test of significance suggests rejecting the null hypothesis of no differences between the means and medians for these two methods of marking in the case of the database application, the measure of the effect size shows that the methods of marking have a small effect, explaining only 1% of the total variance.

We hope that this application of automated grading system integrated with the Moodle learning platform is transferable to other subject areas. We found that our automated grader system had the following advantages for students and staff:

For students:

- Instant feedback on formative, real-time assessment quizzes assists learning and motivation.
- Instant feedback on summative, real-time assessment quizzes provides instant feedback on their success.
- Real-time assessment quizzes provide a structure for the less organized, less clear-thinking students.

For staff:

- Although the initial setup involves a substantial amount of thought and effort, the result of this has great ongoing workload benefits. It enables staff to concentrate on providing ad-hoc feedback to student questions not already covered by the other course resources. This is, therefore, also a student benefit.
- As staff workload is reduced, they are able to do research which underpins the degree course and keeps it current. This is, therefore, also a student benefit.
- Moodle quizzes enable lecturers to receive statistics on the validity of their questions.

For future work, we still need to address issues of plagiarism and the authentication of candidates, as in any other form of assessment in distance education. An appropriate evaluation of the methods of marking should also be undertaken. This means that the same assignment should be marked by a human and an automatic grading system and that the use of the different measures of inter-rater reliability will show any systematic discrepancies between a human marker and an automatic grader.

So what can be said about the future of automated assessment / grading / marking or e-assessment in general? We agree with the vision outlined in Whitelock and Brasher (2007) that

> "traditional paper-based summative assessments will continue to migrate to computer delivery …. Increasingly, aspects of courses that lend themselves to objective question types, or that use assessments based on visualisations of concepts or procedures, will be completed online. These strategies are likely to be combined with short-answer questions, marked by computer and checked by humans, to probe the learner's ability to form links between areas of knowledge". (p. 36)

References

Amelung, M., Piotrowski, M., & Rösner, D. (2006). EduComponents: Experiences in e-assessment in computer science education. *Proceedings of the ITiCSE'06*, Bologna, Italy, 88-92.

Buzzetto-More, N. A., & Alade, A. J. (2006). Best practices in e-assessment. *Journal of Information Technology Education, 5*, 251-269. Retrieved September 27, 2011 from http://www.jite.org/documents/Vol5/v5p251-269Buzzetto152.pdf

Cohen, J. (1992). Statistical power analysis. *Current Directions in Psychological Science, 1*(3), 98-101.

Hill, T. G. (2003). MEAGER: Microsoft Excel automated grader. *The Journal of Computing Sciences in Colleges, 18*(6), 151-164.

Hill, T. G. (2004). Excel grader and Access grader. *ACM SIGCSE Bulletin, 36*(2), 101-105.

Kline, D. M., & Janicki, T. N. (2003). Enhancing economic and finance learning through automated grading of spreadsheet exercises. *Journal of Economics and Financial Education, 2*(2), 23-29.

Koike, H., Akama, K., Chiba, M., Ishikawa, T., & Miura, K. (2005). Developing and e-learning system which enhances students' academic motivation. *Proceedings of the 33rd Annual ACM SIGUCCS Conference on University and College Computing Services*, Monterey, CA, USA, 147-150.

Koike, H., Akama, K., Morita, H., & Mura, K. (2006). Using an automatic marking system for programming courses. *Proceedings of the 34th Annual ACM SIGUCCS Conference on University and College Computing Services*, Edmonton, Alberta, Canada, 173-178.

Malmi, L., Korhonen, A., & Saikkonen, R. (2002). Experiences in automatic assessment on mass courses and issues for designing virtual courses. *Proceedings of the 7th Annual Conference on Innovation and Technology in Computer Science Education*, Aarhus, Denmark, 55-59.

Musham, G. (2004). *Using computer technology to support student assessment.* OET Assignment, University of London.

Russell, G., & Cumming, A. (2005). Automatic checking of SQL: Computerised grading. *International Journal of Learning, 12*(3). 127-134.

Swithenby, S. J. (2006). *E-assessment for open learning*. UK: The Open University.

Tshibalo, A. E. (2007). The potential impact of computer-aided assessment technology in higher education. *South African Journal of Higher Education, 21*(6), 684-693.

Waldman, M., & Ulema, M. (2008). Automated measurement and analysis of effectiveness of teaching selected Excel topics in an introductory IS class. *The Journal of Computing Sciences in Colleges, 23*(5), 73-82.

Whitelock, D. & Brasher, A. (2006, June). *Roadmap for e-assessment.* Joint Information Systems Committee Report.

Whitelock, D. & Brasher, A. (2007). *Effective practice with e-assessment. An overview of technologies, policies and practice in further and higher education*. Joint Information Systems Committee (JISC).

Zhenming, Y., Liang, Z., & Guohua, Z. (2003). A novel web-based online examination system for computer science education. *Proceedings of the 33rd ASEE/IEEE Frontiers in Education Conference*, Boulder, CO, USA, 7-10.

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